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Flora et Vegetatio Sudano-Sambesica (former "Etudes sur la flore et la végétation du Burkina Faso et des pays avoisinants") is a refereed, international journal aimed at presenting high quality papers dealing with all fields of geobotany and ethnobotany of the Sudano-Sambesian zone and adjacent regions. The journal welcomes fundamental and applied research articles as well as review papers and short communications.

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Table of contents | Table des matières | Inhaltsverzeichnis

Flora et Vegetatio Sudano-Sambesica 14, 3-8 Frankfurt, December 2011

The Medicinal Plants of the Woodlands in northern Malawi (Karonga District)

Tina V. Bundschuh, Karen Hahn & Rüdiger Wittig

Summary: In rural Africa, the use of wild plants for medicinal purposes is widespread. Many publications provide regional checklists of medicinal plants, but only a few of these checklists cover Malawi. In the Karongo district, northern Malawi, 30 traditional healers and birth attendants were interviewed regarding their use of woody medicinal plants. This survey reveals that 71 of the 102 woody species that are found in this area are used for a variety of treatments. These medicinal plants are most commonly applied in obstetrics. The favoured wild plants are frequently found in the area; however, three species are perceived as decreasing in abundance.

Keywords: ethnobotany, miombo woodland, sustainability, traditional medicine

Les plantes medicinales de la foret claire en Malawi du Nord (Karonga district)

Résumé: Dans les zones rurales en Afrique, l'utilisation des plantes indigènes à des fins médicinales est largement répandue. En dépit d'une abondante littérature qui présente à l'échelle régionale les listes des plantes médicinales, mais très peu de ces listes concernent le Malawi. Dans le district de Karonga au nord du Malawi, 30 tradithérapeutes et sages-femmes ont été interviewés au sujet de l'utilisation des plantes médicinales ligneuses. Cette étude montre que 71 des 102 espèces ligneuses présentes dans cette région sont utilisées dans divers traitements. Ces plantes médicinales sont en généralement utilisées en obstétrique. Les plantes les plus recherchées sont couramment présentes dans la région. Cependant, on constate que l'abondance de trois espèces diminue.

Mots clés: ethnobotanique, forêt claire miombo, gestion durable, médecine traditionnelle

Die Medizinalpflanzen der Gehölzvegetation in Nord-Malawi (Karonga-Distrikt)

Zusammenfassung: Im ländlichen Afrika ist der Gebrauch von Wildpflanzen für medizinische Zwecke weit verbreitet. Insgesamt gesehen wurden bisher zwar zahlreiche Listen von Heilpflanzen veröffentlicht, der Norden von Malawi wurde aber bisher kaum berücksichtigt.Aus diesem Grunde wurden in Nord-Malawi (Karonga Distrikt) 30 traditionelle Heiler und Geburtshelferinnen bezüglich der medizinischen Nutzung von Gehölzen befragt. Die Untersuchung ergab, dass 71 der insgesamt 102 im Untersuchungsgebiet vorkommenden Gehölzarten für zahlreiche medizinische Anwendungen genutzt werden. Am häufigsten werden Wildpflanzen in der Geburtshilfe angewendet. Alle beliebten Medizinpflanzen kommen im Gebiet häufig vor, für drei der Arten wird aber von den Nutzern eine Abnahme konstatiert.

Schlagworte: Ethnobotanik, Miombo woodland, Nachhaltigkeit, traditionelle Medizin

1 Introduction

In rural Africa, a large number of people depend on the natural resources provided by their environment. Many wild plant species are collected for purposes such as wood fuel, construction, food or traditional medicine. This study reveals that the people living in Malema (District of Karonga, Malawi) and its adjacent areas have a strong demand for traditional medicine. One of the principal reasons for this demand is that the health care system of Malawi is not able to sufficiently provide for the needs of its rural population. To enable the people to overcome this lack of governmental services to a certain degree, it is important to foster the sustainable use of wild plants that can be used for medicinal purposes. Therefore, this study identifies the medicinal species of a representative area and their importance to the area's traditional healers and birth attendants. Specifically, a list is presented of the woody species used as medicinal plants in the environs of Malema, an area that can be regarded as representative of the miombo woodland in northern Malawi. The results of this survey furnish an indication of the degree of sustainability associated with medicinal plants and their use.

2 Study Area

The study area is located in the northern part of Malawi, approximately 10 km south of the city of Karonga. It covers parts of the territories of the villages of Malema, Merere and Mwangolera and of the Ulamwe hill, a protected area whose highest peak reaches 908 m a.s.l. According to the Population and Housing Census (National Statistical Office 1998), Mwangolera, Merere and Malema comprise 404, 140 and 111 households, respectively.

From a biogeographical perspective, the area belongs to the zonobiome of savannas, deciduous forests and grasslands (Breckle 1999). The climate is characterised by a rainy season from mid-November to April followed by a dry season (Fig. 1).

The zonal natural vegetation of most parts of Malawi is generally represented by miombo woodland (Cole 1986), which includes a humid and a dry subtype (White 1983). The dry subtype occurs in the research area. This woodland grows on the shallow stony soils of the rift escarpment, most prominently represented by Ulamwe hill. However, deeper soils and sandy soils are found in the area that slopes

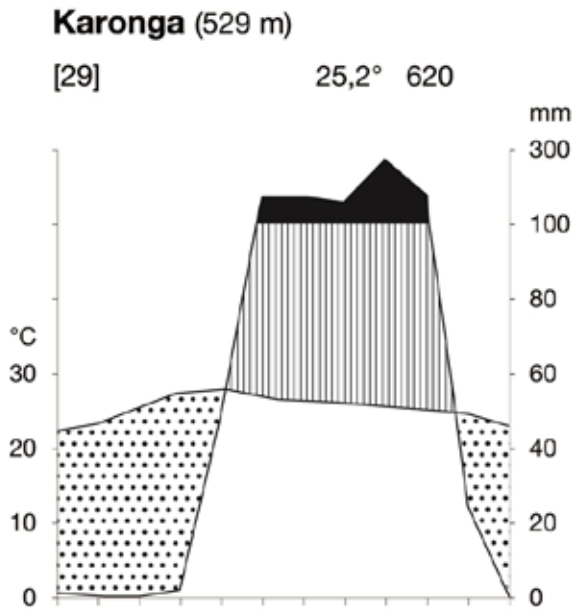

Fig. 1: Climate diagram of Karonga / Diagram ombrothermique de Karonga

towards Lake Malawi. In this area, patterns of farmland and undifferentiated "woodlands and thickets of low altitude" form small island-like thickets between the cultivated fields (Bundschuh et al. 2010).

The main ethnic groups of the study area are Ngonde and Tumbuka. Malawi has an average population density of 105 people per square kilometre. The population density in Karonga District ranges from 50 to 100 people per square kilometre (National Statistical Office 1998). In the villages investigated, most people earn their living from agriculture or by raising cattle and pigs. The most important crops are maize, cassava, cotton, sesamum and the *Borassus* palm. In addition, wild plants are collected for many purposes: for use as fuel, food and spices, for the construction of buildings and furniture and for medicinal purposes.

The nation of Malawi offers free medical services to every citizen. However, many hospitals are poorly equipped (in terms of personnel, equipment and independent financial planning). Therefore, most members of the rural population prefer to consult traditional healers and birth attendants.

3 Methods

To investigate the extent to which woody plants are collected for medicinal purposes, 30 traditional healers and birth attendants living in and near Malema were interviewed concerning their use of medicinal plants. The majority of the persons interviewed belonged to the ethnic groups of Ngonde (15) and Tumbuka (12). All of the interviewees were informed about the aims of the study prior to the interviews and gave their consent for the documenttation and publication of the data presented. The interviews were held with the assistance of an interpreter (either male or female) in a semi-structured format involving a questionnaire (Cunningham 2002) that included the following questions:

- vernacular names of the medicinal plant species area from which the species is collected
- estimated abundance of the species compared to its abundance in the past
- part(s) of the species used
- ailments cured by the species

The item that asked the healers whether the abundance of a plant had changed compared to its abundance in the past included four possible answers: more abundant, no change, slightly less frequent or definitely less frequent . The interviews were supported by an assistant who was familiar with the local plant names and by one of the two interpreters. The findings were verified through field surveys with several of the interviewed healers.

Herbarium material of each species was collected for scientific identification. In addition to the Flora Zambesiaca (Kew Royal Botanic Gardens 2004), "Trees of Southern Africa" (Coates-Palgrave 2002) and the "Field Guide to the Trees and Shrubs of the Miombo Woodlands" (Smith & Allen 2004) were used to determine the species. The determination was verified by staff members of the National Herbarium and Botanic Gardens of Malawi in Zomba.

4 Results

Of the 102 woody species found in the study area, 71 (69 %) are used for medicinal purposes (Appendix). Most of these species are used by only one or two healers or birth attendants. Table 1 contains 25 woody species that were mentioned by at least three of the interviewees. Additionally, the holoparasitic herbaceous *Cassytha filiformis* was included in the list for two reasons: five healers highlighted this plant as very important, and in the local classification epiphytes growing on woody plants are also regarded as woody plants.

The healers collect the plants in the thickets in their immediate vicinity. Only a few healers walk farther, e.g., to the protected area of Ulamwe hill, to collect certain species.

The question about the recent abundance of species compared to the past abundance elicited different responses from different healers about particular species. However, they agreed that, except of three species, none of the plants were formerly more abundant. The three plant species that were considered by several healers to have become increasingly scarce are *Zanha africana* (Sapindaceae), *Ziziphus abyssinica* (Rhamnaceae) and *Securidaca longepedunculata* (Polygalaceae).

The healers primarily collect the roots (90 % of the species), followed by the leaves (36 %) and the bark (12 %). The shoot is used only in a few cases (3 %). The roots and leaves are collected in fresh condition in small amounts, and vertical strips of bark are removed from the eastern and western sides of the stems.

In the majority of cases, the plant material is boiled, and the patients drink the decoction. Certain healers prefer to administer the decoction as porridge. In a few cases, the plant material is extracted with cold water or as an infusion with hot water. This infusion can be applied externally by rubbing it into the skin. For particular purposes, dried plant ma-

Table / Tableau 1: The most preferred medicinal plant species / Les espèces de plantes médicinales les plus recherchées

Scientific name of the plant	Number of times mentioned	Preferred by interviewee	Plant family	Local name (Chitumbuka/ Chinkhonde)
Ziziphus abyssinica	9	2	Rhamnaceae	Kaperekese
Terminalia kaiseriana	8	3	Combretaceae	Mpululu
Annona senegalensis	8	2	Annonaceae	Mnyere
Zanha africana	7	4	Sapindaceae	Mzakaka
Cassytha filiformis	6	5	Lauraceae	Sakazinje
Maytenus senegalensis	6	3	Celastraceae	Chimika
Rhus natalensis	6	2	Anacardiaceae	Nyamtatu
Pseudolachnostylis maprouneifolia	6	1	Euphorbiaceae	Msolo
Ricinus communis (cultivated)	5	3	Euphorbiaceae	Mayembayemba
Byrsocarpus orientalis	5	3	Connaraceae	Muyokayoka
Holarrhena pubescens	5	3	Apocynaceae	Njenje
Asparagus setaceus	5	1	Asparagaceae	Mkhorankhanga
Carica papaya (cultivated)	5	0	Caricaceae	Papaya lyanarume (♂)
Ozoroa reticulata	4	3	Anacardiaceae	Chizimya
Senna siamea	4	2	Fabaceae	Ndengere
Bauhinia petersiana	4	1	Fabaceae	Mpapa
Vernonia colorata	4	0	Asteraceae	Mluluzya
Lannea discolor	3	3	Anacardiaceae	Nakawumbu
Pouzolzia mixta	3	2	Urticaceae	Lukopyo
Vangueria infausta	3	2	Rubiaceae	Maviru
Combretum apiculatum	3	2	Combretaceae	Mlama
Steganotaenia araliacea	3	1	Apiaceae	Mnyongoloko
Allophylus chaunostachys	3	1	Sapindaceae	Nyamtatu
Strychnos madagascariensis	3	0	Loganiaceae	Msongolo
Piliostigma thonningii	3	0	Fabaceae	Mthukutu
Securidaca longepedunculata	3	0	Polygalaceae	Mughuluka

terial is pulverised or, less frequently, burnt to ash. In these cases, application occurs by tattooing. Certain healers also dry the material and shape it so that it can be carried as a talisman (Fig. 2).

Generally, individual healers specialise in a certain practice. Thus, they do not use many different plant species (average 7, maximum 15). Birth attendants need even fewer species (average 3, maximum 7).

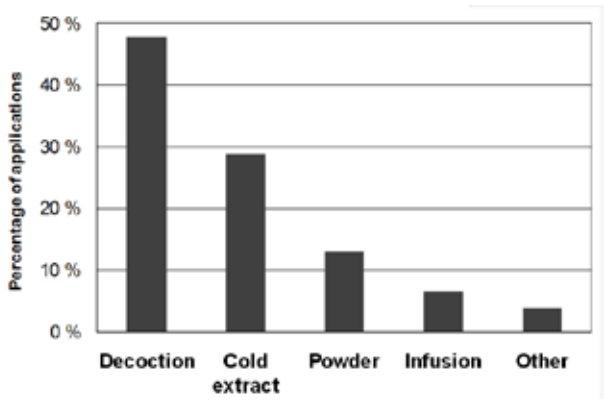

Fig. 2. Mode of preparation of the medicines obtained from woody species / Mode de préparation des médicaments obtenus à partir des espèces ligneuses

The ailments treated by the healers and birth attendants are shown in Figure 3. Most of the plants (38 %) are used in obstetrics. The next most frequent category is the treatment of pulmonary diseases, including pneumonia, coughing or asthma. More than a quarter of the plants are used to ease specific pains (e.g., headache, stomach ache) or general body pains, including gout. The digestive disorders treated by the healers include dysentery and constipation. The children's diseases cited by the healers were generally characterised by fever and were not further specified. The infections cited by the healers were yellow fever, malaria and leprosy. Certain collected wild plants (17 %) are used to treat infertility. This ailment is treated by relatively specialised healers. Mental diseases and epilepsy are also treated by specialists. These diseases are often considered to be of supernatural origin and are generally treated by the performance of rituals. The most common of these rituals, Vimbuza, originated from Tumbuka and is known throughout Malawi. A number of healers use charms for the prevention of danger or thievery or to make a person more attractive. Sexually transmitted diseases (STDs), such as gonorrhoea, were also mentioned. These diseases are often treated by the

same healers who specialise in infertility. A few species are used to treat snake bites in humans and in cows.

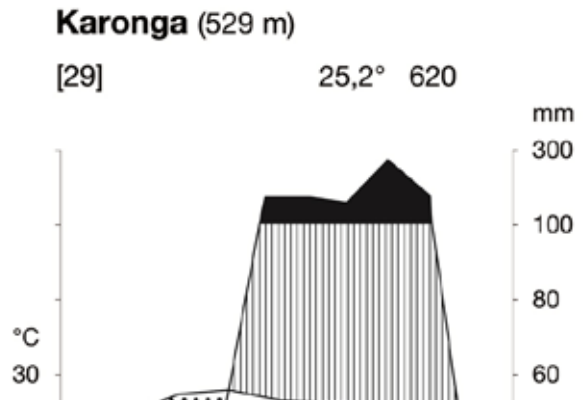

Fig. 3: Use of medicinal plants as indicated in the interviews (percentage of all medicinal plants mentioned). STDs: Sexually transmitted diseases / Usage des plantes médicinales tel que indiqué par les personnes interviewées (pourcentage de toutes les plantes médicinales mentionnées). STDs: Maladies Sexuellement Transmissibles

5 Discussion

The pharmaceutical use of 69 % of the existing woody species represents a relatively high value. Unfortunately, most of the regional works about medicinal plants in Africa provide species checklists without showing the plants in their floristic or vegetational context. Thus, a comparison of the rate of pharmaceutical use found by this study with results from other regions cannot be drawn. However, it is possible to indicate the woody plant species mentioned by the traditional healers of the environs of Malema that are also reported to be of medicinal value in other African regions. Morris (1996) reports information about southern Malawi; Arnold et al. (2002) cover southern Africa (Namibia, Botswana, South Africa); Chhabra et al. (1989, 1993), Dery et al. (1999) and Heine & Legere (1995) address eastern Africa (Tanzania, Uganda and Kenya), and Burkill (2004) provides detailed information about West Africa. The similarities between the determinations of medicinal use made by these previous studies and the findings of this study are summarised in Fig. 4.

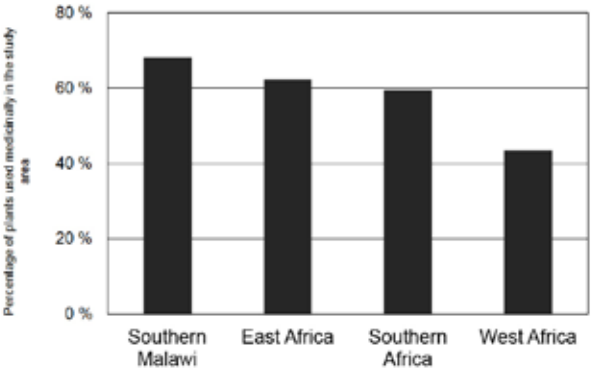

Fig. 4: Percentage of the plants used in Karonga District also used in other regions in Africa. / Pourcentage des plantes utilisées dans le district de Karonga et aussi appliquées dans d'autres régions en Afrique.

Geographically and in terms of its vegetation, Malawi bridges eastern, southern and central Africa. It is rarely included in the main regional studies. However, many of the species used in the area of investigation are well known in other regions of Africa for their medicinal effects (Fig. 4).

The species that were assessed to have decreased in abundance, *Zanha africana*, *Ziziphus abyssinica* and *Securidaca longepedunculata*, were not found in the miombo woodland vegetation. These species occur in the undifferentiated woodlands and in the low-altitude thickets scattered between cultivated lands. Because the need for farmland continues to increase, those relict thickets could vanish. Hence, the thickets and the three species cited here should be a focus of further research or a target for management.

In contrast to the tradition practised in West Africa (Krohmer 2004), but in accordance with that of neighbouring Tanzania (Chhabra et al. 1993), the root is the plant part that is used most frequently in traditional medicine. This custom represents a threat to the individual plant because damage to the roots can destroy the plant. Excessive removal of tree bark similarly represents a threat to the plant. However, at present, the species in use are still available in sufficient numbers. Apparently, the healers are well experienced in the sustainable use of their pharmaceutical plants.

The results of this study regarding the preparation of the plant material agree with the findings of a study conducted in eastern Tanzania (Chhabra et al. 1993). Decoctions are the most favoured type of preparation.

Most of the medicinal plants cited by the healers interviewed in this study are used in obstetrics. This substantial representation is the result of the common need for assistance in giving birth and of the great number of traditional birth attendants and specialised healers in the region. We found many women in the region saying that they would stay in their home environment to give birth and would prefer not to go to the hospital. They would only see a physician if surgical intervention, such as a Caesarean section, were required.

Pulmonary diseases are common in the area for two main reasons. First, the lack of a healthy diet leaves most people vulnerable to infections. Second, most households prepare their food over an indoor fireplace, which fills their homes with unhealthy smoke.

Finally, the threat of HIV/AIDS poses a problem concerning the use of traditional medicinal practices. This condition is difficult for traditional healers to diagnose because it is a syndrome, i.e., a combination of symptoms. Each individual symptom can occur for other reasons or can represent an illness on its own. Furthermore, HIV/AIDS is a socially unacceptable topic and is typically not discussed. Traditional healers are highly respected as a group, and most people in rural Africa consult traditional healers about any type of physical problem. For this reason, traditional healers could play a major role in encouraging more open discussion of HIV/AIDS.

Although certain preferences exist, almost all of the woody plant species are also used for purposes other than medicine. According to own observations, the use of these species as

wood fuel is the most frequent of these other uses (Bundschuh 2008). Currently, the collection of plants for use as wood fuel does not threaten the diversity of woody plant species in the region and does not represent a threat to the abundance of medicinal plants (Bundschuh et al. 2010). However, an increasing demand for wood fuel can be expected due to the development of Karonga and its rising population.

6 Conclusions

The people living in the rural area south of Karonga rely on traditional herbal medicine and have developed a specialised health system. The woody plant species collected for medicinal purposes are mostly collected near the homes of the healers and in thickets located between the cultivated areas. The most important medicinal plant species are still available, but a focus on sustainable use can be recommended for three of these species.

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Literature Cited

Arnold TH, Prentice CA Hawker LC, Snyman, EE Tomalin M, Crouch NR & Pottas-Bircher C (2002): Medicinal and magical plants of southern Africa: an annotated checklist. National Botanical Institute, Pretoria.

Breckle S-W (1999): Walter´s Vegetation of the Earth. Springer-Verlag, Berlin.

Bundschuh TV, Wittig R & Hahn K (2010): The Dry Miombo Woodland in Northern Malawi. Flora et Vegetatio Sudano-Sambesica 13: 22-34.

Burkill HM (2004): The useful plants of West tropical Africa (Vol. VI). Royal Botanic Gardens, Kew.

Chhabra SC., Mahunnah RLA & Mshiu EN (1989): Plants used in traditional medicine in Eastern Tanzania. II. Angiosperms (Capparidaceae to Ebenaceae). J. Ethnopharmacology 25:339-359.

Chhabra SC, Mahunnah RLA & Mshiu EN (1993): Plants used in traditional medicine in Eastern Tanzania. VI. (Sapotaceae to Zingiberaceae). J. Ethnopharmacology 39:83-103.

Coates-Palgrave M (2002): Keith Coates-Palgrave Trees of Southern Africa. Struik Publishers, Cape Town.

Cole MM (1986): The Savannas: biogeography and geobotany. Academic Press Inc., London.

Cunningham AB (2002): Applied Ethnobotany (People, Wild Plant Use & Conservation). Earthscan Publications Ldt., London.

Dery BB, Otsyina R & Ng´atigwa C (1999): Indigenous knowledge of medicinal trees and setting priorities for their domestication in Shinyanga Region, Tanzania. International Centre for Agricultural Research, Nairobi.

Heine B & Legère K (1995): Swahili Plants: An Ethnobotanical Survey. Rüdiger Köppe Verlag, Cologne.

Kew Royal Botanic Gardens (2004): Flora Zambesiaca. Retrieved August 2008, from http://apps.kew.org/efloras/search.do.

Krohmer, J (2004): Umweltwahrnehmung und -klassifikation bei Fulbegruppen in verschiedenen Naturräumen Burkina Fasos und Benins (Westafrika). Frankfurt am Main: Dissertation zur Erlangung des Doktorgrades der Naturwissenschaften.

Morris B (1996): Chewa Medical Botany: A Study of Herbalism in Southern Malawi. Lit., Hamburg

National Statistical Office (NSO) (1998): Malawi Population and Housing Census. Zomba.

Smith, P & Allen Q (2004): Field Guide to the Trees and Shrubs of the Miombo Woodlands. Royal Botanic Gardens, Kew.

White F (1983): The vegetation of Africa. UNESCO, Paris.

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Appendix

List of woody species used for traditional medicine in the area of Karonga and their local names. All species names are approved. Relevant synonyms are provided for certain species. / Liste des plantes ligneuses utilisées en médecine traditionnelle dans la région de Karonga ainsi que leurs noms locaux. Tous les noms d'espèces sont acceptés. Certains noms d'espèces sont suivis de leurs synonymes correspondants.

Species name	Plant family	Local name (Chitumbuka/ Chinkhonde) Synonym
Acacia nilotica (L.) Willd ex Del.	Fabaceae	Chibiriri
Acacia sp.	Fabaceae	Chimbwe
Afzelia quanzensis Welw.	Fabaceae	Kamilang´onga
Allophylus chaunostachys Gilg	Sapindaceae	Nyatatu
Annona senegalensis Pers.	Annonaceae	Mnyere
Anthospermum spec.	Rubiaceae	Mzuula

Species name	Plant family	Local name (Chitumbuka/ Chinhonde)	Synonym
Asparagus setaceus (Kunth) Jessop	Asparagaceae	Mkhorankhanga	
Azanza garckeana (F. Hoffm.) Exell & Hillcoat	Malvaceae	Mtowo	
Bauhinia petersiana Bolle	Fabaceae	Mpapa	
Brachystegia allenii Hutch. & Burtt Davy	Fabaceae	Nguti	
Bridelia cathartica G. Bertol.	Euphorbiaceae	Mguzabango	
Byrsocarpus orientalis (Baill.) Bak.	Connaraceae	Mwawani	*Rourea orientalis*
Canthium glaucum ssp. *frangula* (S. Moore) Bridson	Rubiaceae	Kamyong´onyo	
Carica papaya L.	Caricaceae	Papaya	
Cassipourea mollis (R. E. Fr.) Alston	Rhizophoraceae	Kafulankhwale	
Cassytha filiformis L.	Lauraceae	Sakazinje	
Cissus cornifolia (Bak.) Planch.	Vitaceae	Mlewe („male“)	
Clerodendrum glabrum E. Mey.	Verbenaceae	Kawingawazimu	
Combretum apiculatum Sond.	Combretaceae	Mlama	
Combretum fragrans F. Hoffm.	Combretaceae	Kansewe	*C. adenogonium*, *C. ghasalense*
Commiphora mossambicensis (Oliv.) Engl.	Burseraceae	Chitonto	
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.	Rubiaceae	Chiwaja chikhowo	
Dalbergia nitidula Baker	Fabaceae	Luwewa	
Dichrostachys cinerea (L.) Wight & Arn.	Fabaceae	Mphangala	
Diospyros kirkii Hiern	Ebenaceae	Chigulya	
Diplorhynchus condylocarpon (Muell. Arg.) Pichon	Apocynaceae	Mnthalembe	
Erythrophleum suaveolens (Guill. & Perr.) Brenan	Fabaceae	Mwavi	
Euphorbia matabelensis Pax	Euphorbiaceae	Wulimbo	
Flacourtia indica (Burm. f.) Merr.	Flacourtiaceae	Ndawi	
Grewia stolzii Ulbr.	Tiliaceae	Lusako	
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	Apocynaceae	Njenje	
Hymenodictyon floribundum (Hochst. & Steud.) B.L. Rob.	Rubiaceae	Chitechitechi	
Hymenodictyon parvifolium Oliv.	Rubiaceae		
Indigofera emarginella Steud. ex A.Rich.	Fabaceae	Mwafongo	
Julbernardia globiflora (Benth.) Troupin	Fabaceae	Kamphoni	
Khaya nyasica Stapf ex Bak. f.	Meliaceae	Mbawa	*Khaya anthotheca*
Kigelia africana (Lam.) Benth.	Bignoniaceae	Mfungwe	
Lannea discolor (Sond.) Engl.	Anacardiaceae	Kaumbweumbwe	
Maerua parvifolia Pax	Capparaceae	Luvwi	
Margaritaria discoidea (Baill.) G.L. Webster	Euphorbiaceae	Mpondania	*Phyllanthus discoideus*
Maytenus heterophylla (Eckl. & Zeyh.) N. Robson	Celastraceae	Mbambang´oma	*Gymnosporia buxifolia*
Maytenus senegalensis (Lam.) Exell	Celastraceae	Chimika	*G. senegalensis*
Monodora junodii Engl. & Diels	Annonaceae	Nyampamba	
Olax dissitiflora Oliv.	Olacaceae	Foka	
Olax obtusifolia De Wild.	Olacaceae	Kavundula	
Ormocarpum kirkii S. Moore	Fabaceae	Mbankho	
Ozoroa reticulata (Bak. f.) R. & A. Fernandes	Anacardiaceae	Chizimya	*Heeria insignis*, *Ozoroa insignis*
Piliostigma thonningii (Schumach.) Milne-Redh.	Fabaceae	Mthukutu	
Popowia obovata (Benth.) Engl. & Diels	Anacardiaceae	Ntchinka	*Friesodielsia obovata*
Pouzolzia mixta Solms-Laub.	Urticaceae	Lukopyo	
Pseudolachnostylis maprouneifolia Pax	Euphorbiaceae	Msolo	
Rhus natalensis Bernh. ex Krauss	Anacardiaceae	Nyatatu	
Ricinus communis L.	Euphorbiaceae	Mayembayemba	
Rytigynia adenodonta var. *reticulata* (Robyns) Verdc.	Rubiaceae	Mpokuso	*Rytigynia reticulata*
Rytigynia monantha (K. Schum.) Robyns	Rubiaceae	Mpokuso	
Sclerocarya caffra Sond.	Anacardiaceae	Msere	*Sclerocarya birrea* ssp. *caffra*
Securidaca longepedunculata Fresen.	Polygalaceae	Mughuluka	
Senna siamea (Lam.) H.S. Irwin & Barneby	Fabaceae	Ndengere	*Cassia siamea*
Steganotaenia araliacea Hochst.	Apiaceae	Mnyongoloko	
Sterculia quinqueloba (Garcke) K. Schum.	Sterculiaceae	Mosha	
Stereospermum kunthianum Cham.	Bignoniaceae	Msungawanthu	
Strychnos madagascariensis Poir.	Loganiaceae	Kamira walumba	
Terminalia kaiseriana F. Hoffm.	Combretaceae	Mpululu	
Terminalia stenostachya Engl. & Diels	Combretaceae	Mpokwa	
Vangueria infausta Burch.	Rubiaceae	Maviru	
Vernonia colorata (Willd.) Drake	Asteraceae	Mluluzya	
Vitex payos (Lour.) Merr.	Lamiaceae	Mfuru	
Ximenia caffra Sond.	Olacaceae	Mlewe (edible)	
Zanha africana (Radlk.) Exell	Sapindaceae	Mzakaka	
Ziziphus abyssinica Hochst. ex A. Rich.	Rhamnaceae	Kaperekese	

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

Katharina Schumann, Rüdiger Wittig, Adjima Thiombiano, Ute Becker & Karen Hahn

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

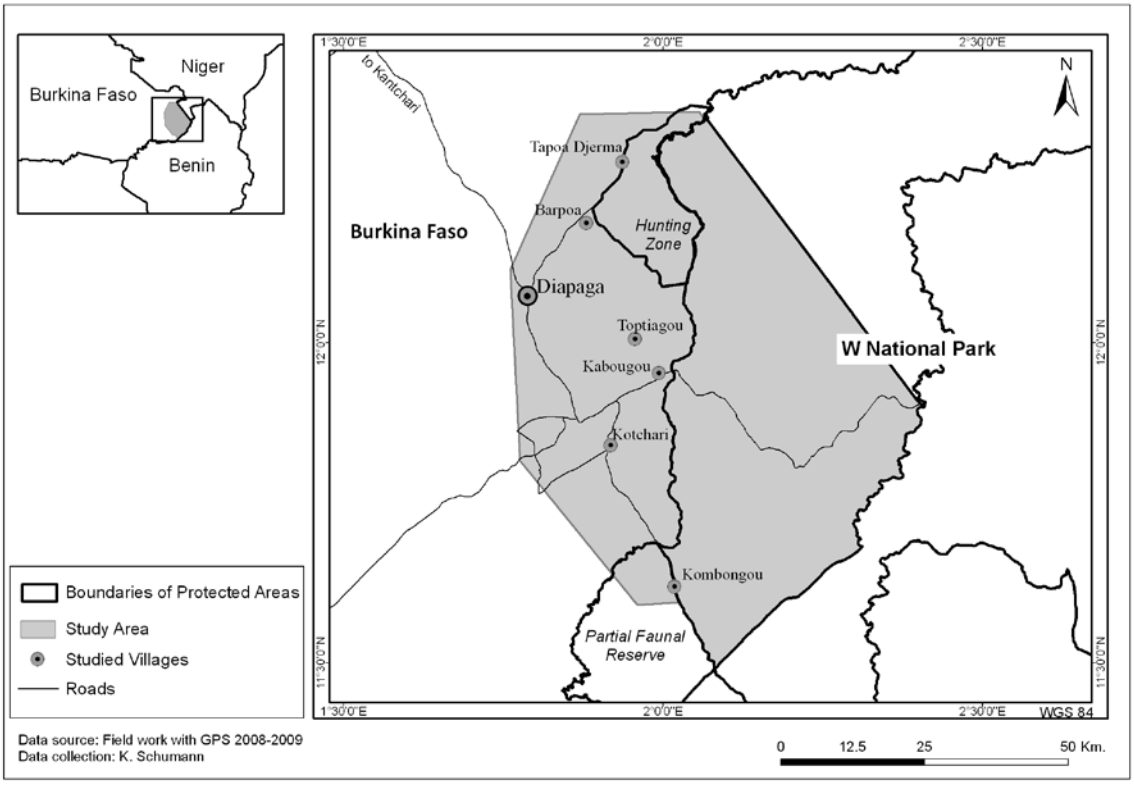

Fig. 1: Study area / Zone d'étude / Untersuchungsgebiet

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 (± 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 newborns 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 sheabutter.
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

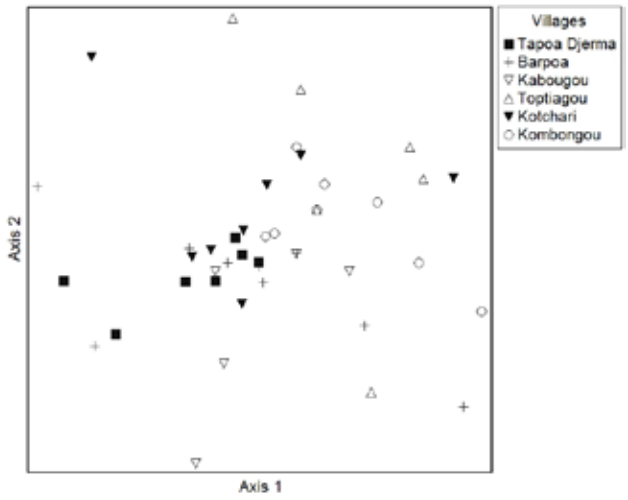

Fig. 3: PCA-scores along the first two axes of PCA analysis of *A. leiocarpa* uses. / Scores issus de l'analyse de la PCA suivant les deux premiers axes des usages d'*A. leiocarpa*. / PCA-Werte der ersten beiden Achsen der PCA Analyse über die Verwendungen von *A. leiocarpa*.
Each dot represents one 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).

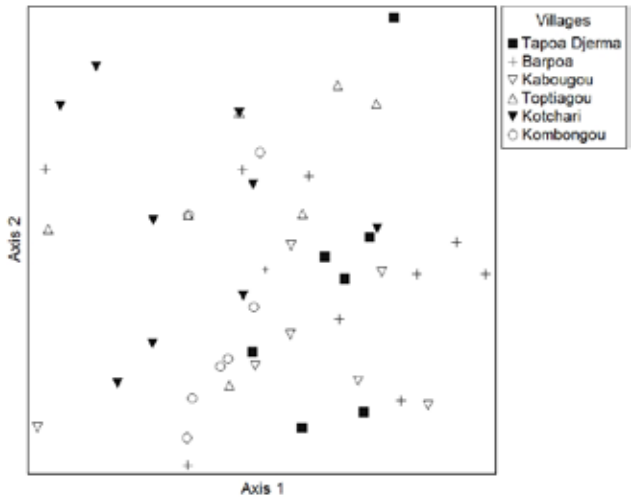

Fig. 4: PCA-scores along the first two axes of PCA analysis of harvesting modes. / Scores issus de l'analyse de la PCA suivant les deux premiers axes des modes de récoltes d'*A. leiocarpa*. / PCA-Werte der ersten beiden Achsen der PCA Analyse über die Sammelpraktiken von *A. leiocarpa*.
Each dot represents 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 medicine. 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/m^3) 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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References

ANDARY C, DOUMBIA B, SAUVAN N, OLIVIER M & GARCIA M (2005): *Anogeissus leiocarpa* (DC.) Guill. & Perr, - in: Jansen, P.C.M., Cardon, D. (eds.): PROTA 3: Dyes and tannins/Colorants et tanins. [CD-Rom]. PROTA, Wageningen, Netherlands.

ARBONNIER M (2002): Arbres, arbustes et lianes des zones sèches d´Afrique de l´Ouest. - second ed. CIRAD, MNHN, Paris.

BELEM B, NACOULMA BMI, GBANGOU R, KAMBOU S, HANSEN HH, GAUSSET Q, LUND S, RAEBILD A, LOMPO D, OUEDRAOGO M, THEILADE I & BOUSSIM IJ (2007): Use of non wood forest products by local people bordering the "Parc National Kaboré Tambi", Burkina Faso. - J. Transdisciplinary Environ. Stud. 6: 1-21.

BURKILL HM (1985-2000): The useful plants of west tropical Africa Vol. I-V. - Royal Botanic Gardens, Kew.

COUTERON P & KOKOU K (1997): Woody vegetation spatial patterns in a semi-arid savanna of Burkina Faso, West Africa. - Plant Ecol. 132: 211–227.

DELVAUX C, SINSIN B & VAN DAMME P (2010): Impact of season, stem diameter and intensity of debarking on survival and bark re-growth pattern of medicinal tree species, Benin, West Africa. - Biol. Conserv. 143: 2664–2671.

DOVIE DBK, WITKOWSKI ETF & SHACKLETON CM (2008): Knowledge of plant resource use based on location, gender and generation. - Appl. Geogr. 28: 311-322.

FAO (1995): Non-wood forest products in nutrition, - in: Non-wood forest products for sustainable forestry, Yogyakarta, Indonesia, January 1995. Non-Wood Forest Products 3. FAO, Rome.

GANSANÉ A, SANON S, OUATTARA LP, TRAORÉ A, HUTTER S, OLLIVIER E, AZAS N, TRAORE AS, GUISSOU IP, SIRIMA SB & NEBIÉ I (2010): Antiplasmodial activity and toxicity of crude extracts from alternatives parts of plants widely used for the treatment of malaria in Burkina Faso: contribution for their preservation. - Parasitol. Res. 106: 335–340.

GAOUE OG & TICKTIN T (2007): Patterns of harvesting foliage and bark from the multipurpose tree *Khaya senegalensis* in Benin: Variation across ecological regions and its impacts on population structure. - Biol. Conserv. 137: 424-436.

GAOUE OG & TICKTIN T (2009): Fulani Knowledge of the Ecological Impacts of *Khaya senegalensis* (Meliaceae) Foliage Harvest in Benin and its Implications for Sustainable Harvest. - Econ. Bot. 63: 256-270.

GUINKO S (1984): La végétation de la Haute Volta. - Ph. D. Thesis, University of Bordeaux III.

HENNENBERG KJ, GOETZE D, MINDEN V, TRAORÉ D & POREMBSKI S (2005): Size class distribution of *Anogeissus leiocarpus* (Combretaceae) along forest-savanna ecotones in northern Ivory Coast. - J. Trop. Ecol. 21: 273-281.

INSD (INSTITUT NATIONAL DE LA STATISTIQUE ET DE LA DÉMOGRAPHIE) (2007): Recensement général de la population et de l´habitation de 2006 du Burkina Faso. - Ministère de l´Administration Territoriale, Burkina Faso.

KRISTENSEN M & LYKKE AM (2003): Informant-based valuation of use and conservation preferences of savanna trees in Burkina Faso. - Econ. Bot. 57: 203–217.

LYKKE AM (2000): Local perceptions of vegetation change and priorities for conservation of woody-savanna vegetation in Senegal. - J. Environ. Manage. 59: 107–120.

LYKKE AM, KRISTENSEN MK & GANABA S (2004): Valuation of local use and dynamics of 56 woody species in the Sahel. - Biodivers. Conserv. 13: 1961–1990.

MCCUNE B & MEFFORD MJ (2006): PC-ORD, Multivariate Analysis of Ecological Data, Version 5.3.1. Software. - Gleneden Beach, Oregon.

MÜLLER J & WITTIG R (2002): L´état actuel du peuplement ligneux et la perception de sa dynamique par la population dans le Sahel burkinabé – présenté à l´exemple de Tintaboora et de Kollangal Alyaakum. - Etudes flor. vég. Burkina Faso 6: 19–30.

PARÉ S, SAVADOGO P, TIGABU M, OUADBA JM & ODÉN PC (2010): Consumptive values and local perception of dry forest decline in Burkina Faso, West Africa. - Environ. Dev. Sustain. 12: 277–295.

R DEVELOPMENT CORE TEAM (2009): R: A language and environment for statistical computing. - R Foundation for Statistical Computing, Vienna.

SACANDE M & SANOGO S (2007): *Anogeissus leiocarpus* (DC.) Guill. & Perr. - Seed Leaflet 109.

SCHUMANN K, WITTIG R, THIOMBIANO A, BECKER U & HAHN K (2010): Impact of land-use type and bark- and leaf-harvesting on population structure and fruit production of the baobab tree (*Adansonia digitata* L.) in a semi-arid savanna, West Africa. - Forest Ecol. Manag. 260: 2035-2044.

SCHUMANN K, WITTIG R, THIOMBIANO A, BECKER U & HAHN K (2011): Impact of land-use type and harvesting on population structure of a non-timber forest product-providing tree in a semi-arid savanna, West Africa. - Biol. Conserv. 144: 2369-2376.

SOBEY DG (1978): *Anogeissus* groves on abandoned village sites in the Mole National Park, Ghana. - Biotropica 10: 87–99.

THIOMBIANO A (2005): Les Combretaceae du Burkina Faso: taxonomie, écologie, dynamique et régénération des espèces. - Habilitation thesis, University of Ouagadougou.

THIOMBIANO A, SCHMIDT M, KREFT H & GUINKO S (2006): Influence du gradient climatique sur la distribution des espèces de Combretaceae du Burkina Faso (Afrique de l´Ouest). - Candollea 61: 189–213.

TICKTIN T, NANTEL P, RAMIREZ F & JOHNS T (2002): Effect of variation on harvest limits for non timber forest species in Mexico. - Conserv. Biol. 16: 691–705.

TICKTIN T (2004): The ecological implications of harvesting non-timber forest products. - J. Appl. Ecol. 41: 11–21.

TLFQ (TRÉSOR DE LA LANGUE FRANCAISE AU QUÉBEC) (2011): http://www.tlfq.ulaval.ca/axl/afrique/burkina.htm - [22 November 2011].

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The use of woody species in northern Benin

Robert Sieglstetter, Karen Hahn & Rüdiger Wittig

Summary: The use of woody species of rural populations in Northern Benin was investigated by semi-structured and open interviews. Of the 129 woody species found in the area, 124 (96%) were mentioned to be used as firewood, for house and furniture construction or preparation of tools, for alimentation, in traditional medicine and/or for other purposes. Our study confirms and underlines the high importance of non timber forest products (NTFPs) for the local population

Keywords: Atakora, Ditamari, ethnobotany, firewood, forest products, traditional medicine, pharmacy, savannah, Sudanian zone, Wama

L'utilisation des espèces ligneuses au nord du Benin

Résumé: L'utilisation des espèces ligneuses par les populations rurales du Nord Benin a été étudiée, moyennant des interviews semi-structurés et ouverts. Parmi les 129 espèces qui ont été trouvées dans la région, 124 (96%) ont été mentionnées comme utilisées, comme bois de chauffe, pour la construction de maisons ou meubles, pour la fabrication d'outils, pour l'alimentation, dans la médecine traditionelle et/ou pour une autre cause. Notre étude confirme et souligne la grande importance des produits forestiers non ligneux (PFNL) pour les populations locales.

Mots clés: Atakora, Ditamari, bois de chauffe, ethnobotanique, produits forestieres, médicine traditionelle, pharmacie, savannah, zone Soudanienne, Wama

Die Nutzung von Gehölzen in Nord-Benin

Zusammenfassung: Mit halbstrukturierten und offenen Interviews wurde die Nutzung von Gehölzpflanzen in Nord-Benin untersucht. Von den 129 Gehölzen, die im Gebiet gefunden wurden, werden 124 (96%) genutzt als Feuerholz, für die Konstruktion von Häusern, Möbeln oder Werkzeugen, für die Ernährung, für die traditionelle Medizin und/ oder andere Zwecke. Unsere Untersuchung unterstreicht damit die große Bedeutung von Gehölzpflanzen für die einheimische Bevölkerung.

Schlagworte: Atakora, Ditamari, Brennholz, Ethnobotanik, Holznutzung, traditionelle Medizin, Pharmazie, Savanne, Sudanzone, Wama

1 Introduction

Human survival and well-being are highly dependent on nature e.g., Costanza & Daly, 1992; Costanza et al., 1997; Myers & Reichert, 1997). Although this statement is true for all regions of the world, it is particularly relevant in the rural population of the so-called developing countries. In these regions, the relationships between people and nature are much more direct than in industrialised countries. The first step towards an understanding of these close relationships and dependencies is the documentation of the services obtained from nature. Accordingly, this paper presents an overview on the use of woody species by the local population in the Atakora region of Benin.

2 Area of investigation

Our study area (Fig. 1) was located in northern Benin (in the department of Atakora), which phytogeographically belongs to the southern Sudanian zone. This zone is characterised by the annual alternation of the dry and wet seasons. The wet season extends from May through November (annual rainfall ca. 1,300 mm/m²). The mean annual temperature is 27 °C. The vegetation is primarily the result of the prevailing type of agriculture, i.e., of shifting cultivation. After several years of tillage, the cleared fields lie fallow for 6 to 15 years. This practice creates a mosaic of recent and fallow crop fields that resembles a savannah landscape. According to Sturm (1994), deciduous dry forests represent the potential natural vegetation of the area.

Within the Atakora department, we selected three villages, Kounadorgou, Péperkou and Tipéti, for our investigation. The dominant ethnic group in Kounadorgou and Tipéti is the Ditamari (or Bétamaribé), whereas Péperkou is a village of the Wama.

3 Methods

During 2000 and 2001, randomly but group-specifically (see below), questionnaires were administered in interviews with selected inhabitants of the three villages. The collection of fuel wood is a task for women. The use of wood for the construction of houses, furniture and tools is a male area of expertise. Therefore, in view of this differentiation in expertise, only the members of the expert group were considered in each case. Equal percentages of men and women were interviewed regarding the use of woody plants for medicinal purposes. In addition, we conducted semi-structured and open interviews (Martin 1995, Schnell et al. 1988).

One year before beginning the survey, the first author of this paper spent three months in the area and visited all of the villages several times to gain the trust of the people. In the years during which the interviews were conducted, he lived in one of the villages from January through March. Furthermore, to ensure the accuracy of the species names provided by the interviewees, the local names of the species were documented and cross-checked (Cunningham 2001).

The keys and descriptions of BRUNEL et al. (1984), GEERLING (1982) and HUTCHINSON et al. (1954) were used for species determinations. The results of these analyses were confirmed in the Herbaria of the Senckenberg Museum, Frankfurt, and the Botanical Museum, Dahlem, Berlin. The herbarium specimens were deposited at FR.

4 Results

Of the 130 woody species found in the area, 124 (Table 1) were mentioned by the interviewees as sources of firewood, as materials for the construction of houses and furniture or the preparation of tools, as food sources, and/or as plants used in traditional medicine. In all, 43 species are used as firewood. However, they are not all equally appreciated. 17 of these species are considered to be of good quality. Of these species, seven are used to produce charcoal. For construction and other "technical" applications (including the preparation of spoons), 30 species are preferentially used. Parts (primarily the fruits or seeds, more rarely the leaves, very rarely the roots and in one case the flowers: Table 1) of 41 species are eaten or applied as spices. A pharmaceutical use was cited for 71 species. Eleven species are used for magical ceremonies, seven for magical ceremonies, four as packaging materials and one as colouring matter.

5 Discussion and Conclusions

Our study confirms and underscores the great importance of forest products (NTPs) to local populations in Africa. This significance was also documented by others (CAVENDISH 2002, KRISTENSEN & BALSLEV 2003, LYKKE et al. 2004, SCHUMANN et al. 2010, BUNDSCHUH et al. 2011). HEUBACH et al. (2011) showed that NTFPs contributed substantially to the income of two other villages in the Atakora region. However, due to climate and land use changes impacting West African savannahs (HAHN-HADJALI & THIOMBIANO 2000, IPCC 2007, SALA et al. 2000, WITTIG et al. 2007), the availability and sustainable use of these ecosystem services are endangered. The security of the rural livelihoods dependent on these services is likewise threatened. We hope that our striking documentation of the high importance of the use of woody species will help to prevent the West African savannah from complete conversion to an impoverished landscape dominated by agro-industrial use.

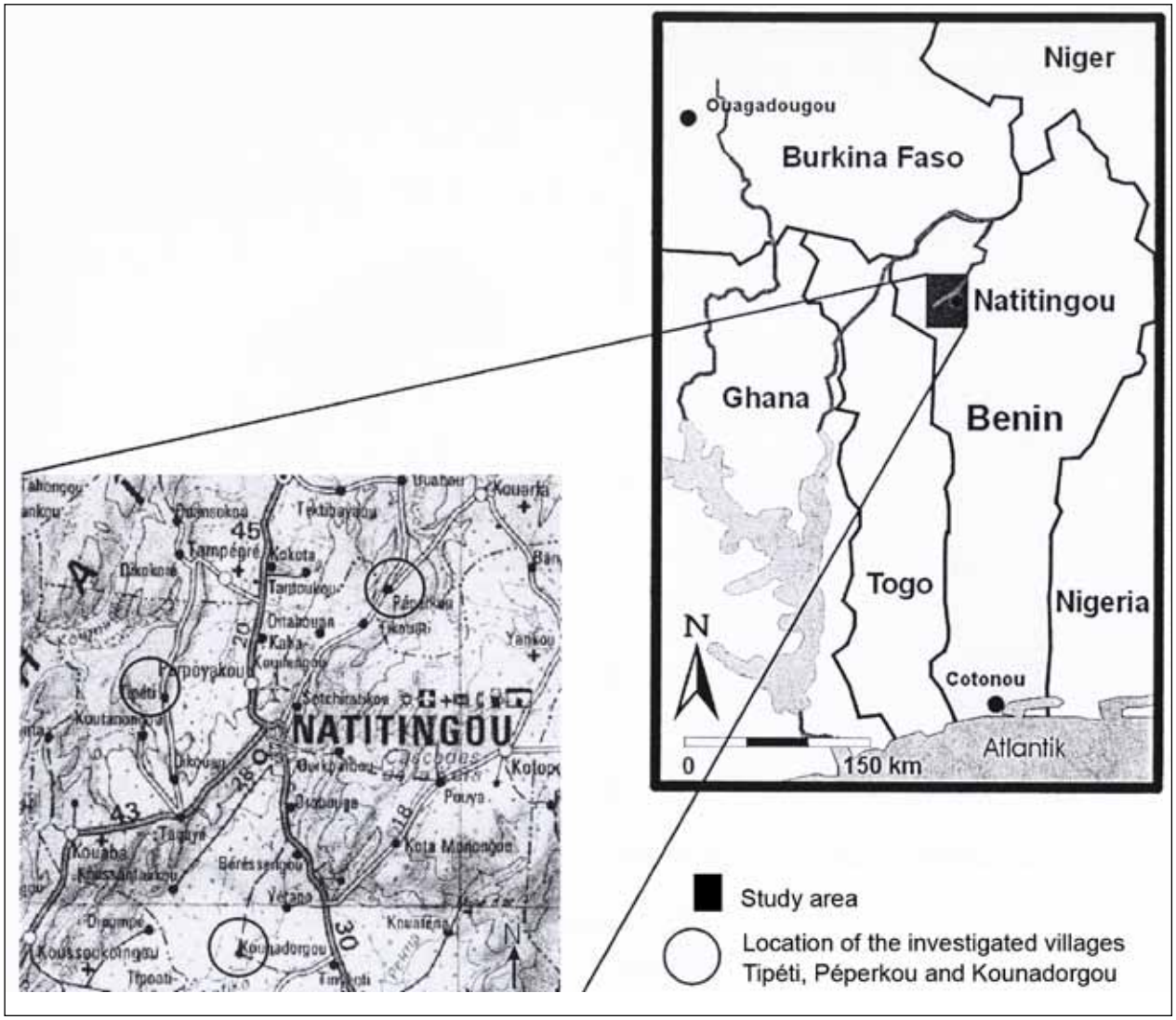

Fig. 1: Study area and location of the investigated villages/ Zone d'étude et position des villages investigés/ Untersuchungsgebiet und Lage der untersuchten Dörfer

Table / Tableau / Tabelle 1: The use of woody species / l´utilisation des especes lingneuxes / die Nutzung von Holzpflanzen

Species	Fw	L & T	Aliment.	Ph	H	Magic	Other
Acacia dudgeonii		+					Z
Acacia hockii		+					Z
Adansonia digitata			L,S,F	+			
Afzelia africana				+		+	I
Albizia zygia	0			+			
Allophyllus cobbe					+		
Anacardium occidentale	0		F,S				
Annona senegalensis			F,L	+		+	
Anogeissus leiocarpa		+	F				
Anthocleista nobilis				+			
Azadirachta indica				+			
Baissea multiflora c.f.			L				
Balanites aegyptiaca				+			
Bambusa vulgaris		+					
Berlinia grandiflora		+	L				
Blighia sapida			F	+	+		
Bombax costatum			B	+			
Borassus aethiopium			S	+		+	M
Breonadia salicina					+		
Bridelia ferruginea		+	F				
Bridelia scleroneura			F				
Burkea africana	+, C	+					
Byrsocarpus coccineus				+			
Canthium multiflorum							C
Canthium venosum		+					F
Cassia sieberiana		+		+			
Ceiba pentandra				+			
Citrus spec.			F	+			
Clematis hirsuta				+			
Cochlospermum tinctorium			R				
Combretum collinum	+				+		
Combretum fragrans	0			+			
Combretum molle		+		+			
Combretum nigricans							
Commiphora excelsa				+			
Crossopteryx febrifuga	+, C	+		+			
Cussonia barteri				+			
Daniella oliveri	+			+			
Detarium microcarpum	+		F	+			
Dichrostachys cinerea	0	+		+		+	Z
Dioscorea dumetorum			R				
Dioscorea togoensis			R				
Diospyros mespiliformis		+	F				
Ekebergia senegalensis	0						
Entada africana	+, C			+			
Erythrina senegalensis				+			
Erythrophleum africanum	+, C	+					G
Euphorbia unispina				+		+	
Fadogia agrestis			F	+			
Fadogia erythrophloea	0			+			
Ficus capensis	+						F
Ficus gnaphalocarpa			F				
Garcinia ovalifolia	+		F		+		
Gardenia aqualla				+			
Gardenia erubescens	0		F	+		+	Z
Gardenia tenuifolia				+			
Grewia bicolor	0		F				
Grewia cissoides			F				
Grewia mollis	0		F				
Haematostaphis barteri			F	+			
Hexalobus monopetalus	0	+	F				R
Hymenocardia acida	0	+	L,S,F	+			

Species	Fw	L & T	Aliment.	Ph	H	Magic	Other
Isoberlinia doca	+	+		+			P
Isoberlinia tomentosa	0	+					P
Khaya senegalensis	0	+		+			
Lannea acida	0		F	+			
Lannea microcarpa			F				
Lophira lanceolata		+	S	+			
Mangifera indica			F	+			
Manilkara multinervis	0	+			+		
Margaritaria discoidea	0						
Maytenus senegalensis				+			
Monotes kerstingii	+	+		+			
Nauclea latifolia			F	+			
Ochna schweinfurthiana				+			
Oncoba spinosa							
Opilia celtidifolia				+			
Oxytenanthera abyssinica		+		+			
Ozoroa insignis							S
Parinari curatellifolia	0			+			
Parkia biglobosa	0		F				
Paullinia pinnata			F	+			
Pavetta crassipes				+			
Pentadesma butyracea	+	+	S				
Pericopsis laxiflora	+, C	+		+			
Phyllanthus muellerianus	0		F	+			
Piliostigma thonningii				+			P,R
Prosopis africana				+	+		
Protea madensis				+			
Pseudocedrela kotschii	0						
Psorospermum senegalense				+	+		
Pteleopsis suberosa		+		+			R
Pterocarpus erinaceus	+, C	+		+			
Pterocarpus santalinoides			F				
Quassia undulata		+					
Rhaphia sudanica		+	S			+	
Sclerocayia birrea			F				
Securidaca longepedunculata				+			
Securinega virosa						+	M,I
Smilax kraussiana				+			
Steganotaenia araliacea				+	+		
Sterculia setigera			S	+	+		
Stereospermum kuntianum				+			
Strophanthus sarmentosus				+			G
Strychnos innocua						+	
Strychnos spinosa			F	+			I
Swartzia madagascariensis	0	+					
Syzygium guineense	0			+			
Tamarindus indica			F	+			
Tapinanthus bangwensis						+	
Tapinanthus dodoneifolius						+	
Terminalia avicennioides	0						
Terminalia glaucescens	+	+		+	+		
Terminalia laxiflora	0						
Tricalysia chevalieri				+			
Trichilia emetica				+			
Uapaca togoensis	+, C			+			P
Vitellaria paradoxa	0		S	+	+		
Vitex doniana			F				
Vitex simplicifolia	0		F				
Ximenia americana			R	+			
Zanha golungensis	+						
Zanthoxylum zanthoxyloides			R	+			
Ziziphus mucronata				+			

Fw Firewood: + preferred, 0 also used, C Charcoal production,
L&T Lumber and tools
Aliment. Alimentation: B Flowers, F Fruits, L Leaves, R Roots, S Seeds
Ph Pharmacy, traditional medicine
H Hygiene
Magic used in magical ceremonies
Others: C Coloration, F Fishing, G Poison, I Musical Instruments, M Mats, P Packaging Material, R Ropes, S Spears, Z Fencing

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References

Brunel JF, Hiepko P & Scholz H (1984): Flore analytique du Togo – Phanerogames. GTZ, Berlin, Eschborn.

Bundschuh TV, Hahn k & Wittig R (2011): The Medicinal Plants of the Woodlands in Northern Malawi (Karonga District).- Flora Veg. Sudano-Sambesica 14: 3-9.

Cavendish W (2002): Quantitative methods for estimating the economic value of resource use to rural households. Uncovering the Hidden Harvest: Valuation Methods for Woodland and Forest Resources. Earthscan publications Ltd., London.Costanza and Daly, 1992.

Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, Oneill RV, Paruelo J, Raskin RG, Sutton P & van den Belt M (1997): The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Geerling C (1982): Guide de terrain des lignieux saheliens et soudano-guineens. Veenman & Zoonen, Wageningen.

Hahn-Hadjali K & Thiombiano A. (2000): Perception des espèces en voie de disparition en milieu gourmantché (Est du Burkina Faso). Berichte des Sonderforschungsbereich 68: 285-297.

Heubach K, Wittig R & Nuppenau E-A & Hahn, K. (2011): The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural west African communities: A case study from northern Benin. Ecol. Econom.; doi:10.1016/j.ecolecon.2011.05.015

Hutchinson J, Dalziel JN & Keay RWJ (1954): Flora of West Tropical Africa. Millbank, London.

IPCC (2007): Climate Change 2007: The Physical Science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge.

Kristensen M & Balslev H (2003): Perceptions, use and availability of woody plants among the Gourounsi in Burkina Faso. Biodiversity and Conservation 12: 1715-1739.

Lykke AM, Kristensen MK & Ganaba S (2004): Valuation of local use and dynamics of 56 woody species in the Sahel. Biodiversity and Conservation 13(10): 1961-1990.

Myers JP & Reichert JS (1997): Perspectives on Nature's Services, in: Daily, G.C. (Ed.), Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

Sala OE, Chapin III FSC, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Huber-Sanwald E, Huenneke LF, Jackson RB, Kinzig A, Leemans R, Lodge DM, Mooney HA, Oesterheld M, Poff NL, Sykes MT, Walker BH, Walker M & Wall D (2000): Global Biodiversity Scenarios for the Year 2100. Science 287: 1770-1774.

Schumann K, Wittig R, Thiombiano A, Becker U & Hahn K (2010): Impact of land-use type and bark- and leaf-harvesting on population structure and fruit production of the baobab tree (*Adansonia digitata* L.) in a semi-arid savanna, West Africa. Forest Ecology and Management 260: 2035-2044.

Wittig R, König K, Schmidt M & Szarzynski J (2007): A study of climate change and anthropogenic impacts in West Africa. Environmental Science and Pollution Research 14: 182-189.

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The vegetation of recently fallowed *Masakwa* fields in the Chad basin

Mandingo Ataholo & Rüdiger Wittig

Summary: On the clay plains surrounding Lake Chad (West Africa: northern Sudanian and southern Sahelian zone), certain varieties of pearl millet (*Sorghum bicolor*), commonly referred to as *Masakwa*, are cultivated during the dry season. Recently fallowed *Masakwa* fields support a particular progression of pioneer vegetation. In the first year of fallow, the pioneer vegetation typically belongs to the class Echinochloetea colonae Wittig 2005 and can be classified as Hygrophiletum auriculatae sensu lato. Approximately half of the stands consist of the Hygrophiletum auriculatae Ataholo 2002 *sensu stricto*, whereas the other half is primarily composed of a *Celosia argentea-Hibiscus trionum* community. After two years of fallow, the vegetation is typically formed by the Sorghetum arundinacei Ataholo 2002, which, in a few cases, can also occur in the first fallow year.

Keywords: Echinochloetea colonae, *firgi*, Hygrophiletum auriculatae, Nigeria, Sahelian zone, Sorghetum arundinacei, *Sorghum bicolor*, Sudanian zone

La végétation des jeunes jachères d'anciens champs de *Masakwa* dans le Bassin du Tchad

Résumé: Sur les sols argileux de la plaine autour du Lac Tchad (Afrique de l'Ouest: zones Soudanienne au Nord et Sahélienne au Sud), des variétés particulières de petit mil (*Sorghum bicolor*) toutes regroupées sous le terme *Masakwa*, sont cultivées pendant la saison sèche. Les jeunes jachères issues d'anciens champs de *Masakwa* forment un type particulier de végétation pionnière. Cette végétation au cours de la première année et dans la majorité des cas, fait sans doute partie de la classe d'Echinochloetea colonae Wittig 2005, et classée comme Hygrophiletum auriculatae *sensu lato*. Près de la moitié des peuplements constitue le Hygrophiletum auriculatae Ataholo 2002 sensu lato, tandis que l'autre moitié est formée en majorité par le *Celosia argentea-Hibiscus trionum*. Dans les champs de deux ans, on retrouve normalement le Sorghetum arundinacei Ataholo 2002, qui dans certains cas apparait déjà au cours de la première année de jachère.

Mots clés: Echinochloetea colonae, *firgi*, Hygrophiletum auriculatae, Nigeria, Sorghetum arundinacei, *Sorghum bicolor,* zone Sahelienne, zone Sudanienne

Die Vegetation junger Brachen der *Masakwa*-Felder in der Tschad-Ebene

Zusammenfassung: Auf den Tonebenen des Tschadbeckens (West Afrika: südliche Sahel- und nördliche Sudanzone) werden bestimmte Sorten der Perl-Hirse (*Sorghum bicolor*) unter dem Sammelnamen *Masakwa* kultiviert. Junge Brachen von *Masakwa*-Feldern tragen im ersten Jahr in der Regel eine zur Klasse Echinochloetea colonae Wittig 2005 gehörende Pioniervegetation, die im weiteren Sinne dem Hygrophiletum auriculatae Ataholo 2002 zugeordnet werden kann. Etwa die Hälfte der Bestände repräsentiert das Hygrophiletum auriculatae *s.str*., die ancdere Hälfte wird meist von einer *Celosia argentea-Hibiscus trionum*-Gesellschaft gebildet. Auf zwei Jahre lang brach liegenden Feldern findet man meist das Sorghetum, arundinacei Ataholo 2002, das in seltenen Fällen auch gleich im ersten Brachejahr auftreten kann.

Schlagworte: Echinochloetea colonae, *firgi*, Hygrophiletum auriculatae, Nigeria, Sahelzone, Sorghetum arundinacei, *Sorghum bicolor,* Sudanzone

1 Introduction

Within the clay planes surrounding Lake Chad (West Africa: northern Sudanian and southern Sahelian zone), certain varieties of pearl millet (*Sorghum bicolor*; see Dahlberg 2001), commonly called *Masakwa*, are cultivated during the dry season (Olabanji 1999, Neumann 2001). Because cropping in the dry season within the Sudanian and Sahelian zone represents a particularity, the fallow vegetation of these fields is of great interest for vegetation science. Furthermore, in the context of increasing populations (Krings 2002), the shrinking of Lake Chad (Thiemeyer 2002) and climate change, it is doubtful whether the very laborious traditional dry season cultivation will be maintained in the future. Therefore, we present a study of the fallow vegetation of the dry season fields at Lake Chad.

2 Area of investigation

All relevés were taken in the year 1995 in the area near Marte and Ngala (Nigeria) according to the method of Braun-Blanquet (1964). The area of our investigation was located in the Sudanian zone near the border of the Sahelian zone (White 1983). In this area, as well as in other areas in the vicinity of Lake Chad, a particular traditional method of dry season cultivation is used, which is based on the high water retention capacity of the soils that have developed on the lagoonal plains of Chad (called *firgi* in the Kanuri language). The soils and landscape in the vicinity of the Nigerian shore of Lake Chad were intensively surveyed by researchers from the Goethe-University of Frankfurt (Germany) within the framework of the Collaborative Research Center 268 (*Sonderforschungsbereich 268*). Additional detailed informati-

on on this area can be obtained from publications resulting from this investigations (e.g., FRANKE-SCHARF 1997, 2000, KIRSCHT 2001, NEUMANN 2001, SKORUPINSKY & FRANKE-SCHARF 1997, THIEMAYER 1997a, b) or from the review of FRANKE-SCHARF et al. (2004). The linguistic background of the term *Masakwa* was addressed by LÖHR (2001).

Because of the low infiltration rate of clay soils, dykes of 0.5 to 0.75 m high have been built around the fields to impound rainwater, prevent run-off and increase infiltration. In August, which is part of the rainy season, sorghum nurseries are prepared while the dry season fields are still flooded. Several weeks later, when the firgi are dry, the spontaneous vegetation ("weed vegetation") of the fields is removed, and four- to six-weeks-old seedlings are planted (for additional details of the planting procedure, see OLABANJI 1999). At this time, the surface of the *firgi* has become dry and hard and becomes largely impenetrable for the roots of germinating weeds. Therefore, one or two weeding events are sufficient to achieve a minimal weed cover. The complete potential weed community can only be observed on recently fallowed fields.

3 RESULTS

We identified two plant communities on the fallowed *Masakwa* fields: Hygrophiletum auriculatae *sensu lato* (3.1) and Sorghetum arundinacei (3.2).

3.1 Hygrophiletum auriculatae *sensu lato*

After one year of fallow, *Masakwa* fields are covered by dense vegetation (covering 65 – 98 %; average 87 %) that is typically dominated by one or several of the species *Celosia argentea*, *Hibiscus trionum*, *Cyperus esculentus* and/or *Hygrophila auriculata*, *Momordia balsamina* and, more rarely, by *Ipomoea aquatica*. Nearly all of the species that occur with medium to high constancy prefer humid or temporarily wet soils. According to LE BOURGEOIS & MERLIER (1993), a high proportion of these species are classified as indicators of vertisols and/or clay or a high soil pH. ATAHOLO (2002) demonstrated that approximately 75 % of the species found in this community are indicators of heavy soils, and 55 % are indicators of alkaline soils. Obviously, the vegetation of fallowed *Masakwa* fields closely mirrors the soil conditions (MORDI et al. 1991) of the *firgi*.

Greater than 50 % of the relévés taken of this vegetation (Table 1, No. 1 – 7) can be identified as belonging to the Hygrophiletum auriculatae *s. str.*, which was described by ATAHOLO (2002). This association is one of the two communities that represent the class Caperonietea palustris Ataholo 2002; however, no valid description of this class presently exists. WITTIG (2005) assigned this community to the alliance Aeschynomenion indicae Wittig 2005 within the class Echinochloetea colonae Wittig 2005. In a broader sense, the remaining five relévés also belong to the Hygrophiletum auriculatae because of their similar species composition and identical habitat. When the guidelines of BRAUN-BLANQUET (1964) are strictly followed, these relévés must be regarded as representing a rankless community for which ATAHOLO (2002) has proposed the name *Celosia argentea-Hibiscus trionum* community.

3.2 Sorghetum arundinacei Ataholo 2002 nom. corr.

After two years, fallowed fields are covered by the Sorghetum arundinacei Ataholo 2002 nom. corr. (Table 2), which is a grass-dominated vegetation that covers 80 – 95 % (average 88 %) and often reaches a height of 3 m. In most stands, *Sorghum arundinaceum* is dominant, in a few cases *Momordica balsamina* shows the highest cover. Rarely, *Merremia emarginata*, *Echinochloa colona* or *Sorghum bipinnatum* were found to be codominant. Similar to the one-year fallows, *Hibiscus trionum*, *Celosia argentea* and *Caperonia palustris* show high to very high constancy. According to ATAHOLO (2002), indicators of clay and of alkaline soils are strongly represented, which is similar to the vegetation of the recently fallowed fields described above. In a few cases, the Sorghetum arundinacei was observed in one-year fallows. These stands, which are represented by relévé No. 2 in Table 2, were of a much lower height than those of the older fallowed fields.

Because only a few relévés are available, the position of this association within the phytosociological system is arguable. Therefore, it is desirable to obtain additional relévés of this community as well as of the pioneer vegetation of other temporarily inundated argillaceous soils in the Sudanian and Sahelian zone.

4 DISCUSSION

The ecological conditions of recently fallowed and temporarily inundated fields are very similar to that of disturbed areas at the shores of lakes or in depressions with argillaceous soils and of the dry fallen soils of temporary waters (called *mares* in French). In all cases, wet bare soil exists and remains humid during the first weeks of the dry season. Therefore, germination conditions are excellent and competition is, at first, very low. Therophytes dominate the resulting vegetation, but seedlings of perennial species common in later successional stages, and of the adjacent communities, might be present. The therophytes comprise three groups:

- Ubiquitious species found at the majority of disturbed sites,
- Species that mainly occur in cultivated fields (i.e., agricultural weeds *s.str*),
- Species with a unique ecological adaptation to these temporarily inundated (or temporarily wet) and periodically disturbed habitats. These species form the core of the class Echinochloetea colonae Wittig 2005.

The Hygrophiletum auriculatae represents a key example of this type of vegetation: the class Echinochloetea colonae is represented by its name-giving species (*Echinochloa colona*) and by a character species of one of its associations (*Hygrophila auriculata*). Agricultural weeds *s.str.* are present (e.g., *Celosia argentea*, *Corchorus olitorius* and *Commelina nigritana*), and *Sida alba* represents the group of ubiquists. *Cyperus esculentus*, *Oryza barthii* and *Echinochloa stagnina* are mainly considered reed species.

As the succession continues, species that are taller than the aforementioned plants become dominant such that the dimensions of the vegetation are completely altered. The

Table / Tableau 1: Hygrophiletum auriculatae and *Celosia argentea-Hibiscus trionum* **community**

No.	1	2	3	4	5	6	7	8	9	10	11	12
No. in Table 57 of Ataholo 2002	4	5	12	3	6	16	7	2	8	10	11	14
vegetation cover (%)	95	90	90	80	98	95	80	75	90	65	80	95
height of the vegetation (m)	0.6	0.6	0.5	0.5	0.6	0.4	0.8	0.4	0.5	0.3	0.4	0.4
relévé area (m2 x 10)	40	60	60	40	50	90	12	50	60	40	90	90
C Hygrophyletum auriculatae												
Hygrophila auriculata	5	2	1	2	3	2	+	.	.	.	.	.
C and D* of the Aeschynomenion indicae												
Caperonia palustris	1	+	1	1	1	.	.	.	1	1	1	2
Cyperus esculentus	.	.	2	2	2	3	.	2	4	2	+	3
Ipomoea aquatica	.	1	2	3	.	1	1	1	1	.	.	1
Oryza barthii	1	1	.	.	3	.	.	.	.	.	.	.
Aeschynomene indica	.	.	.	2	.	.	.	.	.	+	+	.
Echinochloa stagnina	.	.	.	.	.	1	.	.	.	.	.	.
Centrostachys aquatica	.	.	.	.	.	.	1	.	.	.	.	.
C of the Echinochloetea colonae												
Echinochloa colona	.	.	.	.	1	1	3	.	3	.	.	.
Indicators of clay and/or vertisols**												
Celosia argentea	1	4	3	1	1	2	+	2	1	1	2	2
Ocimum canum	.	+	.	.	+	.	+	+	+	+	+	.
Merremia emarginata	.	.	.	.	.	.	+	1	1	.	.	1
Corchorus olitorius	.	.	.	.	.	.	1	.	+	.	.	2
Phyllanthus maderaspatensis	.	.	.	.	.	.	.	1	1	1	.	.
Corchorus fascicularis	.	+	.	.	.	.	.	.	+	.	.	.
companions												
Hibiscus trionum	2	2	4	.	1	2	.	2	1	3	2	3
Momordica balsamina	.	.	.	.	.	4	1	3	.	2	.	3
Sida alba	.	.	.	.	+	+	.	+	.	.	+	.
Commelina nigritana	.	3	.	.	.	.	.	2	2	.	.	.
Aeschynomene americana	1	.	.	.	+	.	.	.	.	.	.	.
Abutilon pannosum	.	.	.	.	.	1	.	.	.	.	.	2
Aeschynomene sensitiva	.	.	.	.	.	1	.	.	.	.	.	2
Euphorbia forsskalii	.	.	.	.	.	.	+	+	.	.	.	.
Calotropis procera	.	.	.	.	.	.	+	.	.	+	.	.
Lagera oloptera	.	.	.	2	.	.	.	.	.	.	.	.
Acroceras amplectens	.	.	.	.	.	.	3	.	.	.	.	.
Acacia seyal (juv.)	.	.	.	.	.	.	2	.	.	.	.	.
Hibiscus panduriformis	.	.	.	.	.	.	1	.	.	.	.	.
Chloris barbata	.	.	.	.	.	.	1	.	.	.	.	.
Sida alba	.	.	.	.	.	.	1	.	.	.	.	.
Merremia hederacea	.	.	.	.	.	.	.	.	3	.	.	.
Phyllanthus amarus	.	.	.	.	.	.	.	.	1	.	.	.
Chlorophytum pusillum	.	.	.	.	.	.	.	.	1	.	.	.
Pennisetum violaceum	.	.	.	.	.	.	.	.	.	.	.	1

Additionally with + in relévé No.1: *Leucas martinicensis*; **in No.2**: *Cucumis melo* var. *agrestis*; **in No.7**: *Citrullus colocynthis, Sesbania leptocarpa*, *Indigofera senegalensis*, *Leptadenia hastata*, *Cassia tora*, *Achyranthes sicula*, *Panicum mueense*; **in No.9**: *Eragrostis atrovirens*, *Ipomoea coptica*, *Portulaca oleracea*, *Commelina africana* var. *africana*; **in No.12**: *Ludwigia octovalvis*.

* all species of reed communities and other amphibious habitats

** mentioned by LE BOURGEOIS & MERLIER (1995)

Table / Tableau 2: Sorghetum arundinacei

relévé no.	1	2	3	4	5
Table no. in Ataholo (2002)	58	58	58	57	57
vegetation cover (%)	90	80	85	90	95
height of the vegetation (m)	3	3.5	3	0.4	1.5
relévé area (a)	9	9	9	9	5
Character species					
Sorghum arundinaceum	5	4	3	2	3
Other species					
Hibiscus trionum	1	2	2	1	2
Momordica balsamina	2	2	2	4	1
Celosia argentea	+	+	2	2	.
Echinochloa stagnina	+	1	1	1	.
Abutilon pannosum	+	1	2	+	.
Phyllanthus maderaspatensis	+	+	+	+	.
Cyperus esculentus	2	2	2	2	.
Caperonia palustris	1	2	2	.	1
Sida alba	+	1	+	.	.
Merremia emarginata	.	+	+	3	.
Gynandropsis gynandra	+	+	.	.	.
Euphorbia forsskalii	+	+	.	.	.
Hibiscus scotelii	+	+	.	.	.
Echinochloa colona	.	+	.	.	3
Corchorus olitorius	.	.	+	.	2
Leucas martinicensis	.	.	1	.	.
Ipomoea aquatica	.	.	.	1	.
Aeschynomene sensitiva	.	.	.	1	.
Sorghum bipennatum	.	.	.	.	3
Hibiscus panduriformis	.	.	.	.	2
Bidens pilosa	.	.	.	.	1

Additionally with + in relévé No.1: *Pennisetum violaceum*, *Rhyncosia minima*; **in No.3**: *Cassia obtusifolia*, *Aeschynomene indica*, *Bidens pilosa*; **in No.4**: *Phyllanthus amarus*.

species composition, however, does not substantially vary: eight of the eleven species with a constancy class of III - V in Hygrophiletum auriculatae also occur in Sorghetum arundinacei at a constancy class III or greater; and also eight of the eleven species that occur with intermediate to very high constancy in the Sorghetum arundinacei are present in Hygrophiletum auriculatae at class III or greater.

As shown above, the Hygrophiletum auriculatae clearly belongs to the Echinochloetea colonae. Further investigations are needed to clarify whether the Sorghetum arundinacei also can be assigned to this vegetation class or whether it forms the core of a separate class, i.e., the Caperonietea palustris proposed by ATAHOLO 2002.

REFERENCES

ATAHOLO M (2002): Pflanzensoziologische Untersuchungen der Segetalvegetation in der Sudanzone Westafrikas. Diss., J.W. Goethe-Universität, Frankfurt am Main.

BRAUN-BLANQUET, J (1964): Pflanzensoziologie - Grundzüge der Vegetationskunde. - Springer, 3. Aufl., Wien, 865 p.

DAHLBERG JA (2001): Classification of masakwa sorghum from Lake Chad. Ber. SFB 268 17: 15-22.

FRANKE-SCHARF I (1997): Landnutzungswandel im nigerianischen Tschadbecken. Kartierungen aus Luftbildern von 1957 bis 1990. Ber. SFB 268 9: 35-51.

FRANKE-SCHARF I (2000): Integration of land use and related information within a geographic information system of the Chad Basin in NE-Nigeria. Ber. SFB 268 14: 105-114

FRANKE-SCHARF I, KIRSCHT H, KRINGS M, PLATTE E & THIEMEYER H (2004): Der Tschadsee: Seespiegelschwankungen und wechselnde Nutzungspotenziale. In ALBERT KD, LÖHR, D. & NEUMANN K (eds.): Mensch und Natur in Westafrika. Ergebnisse aus dem Sonderforschungsbereich 268 "Kulturentwicklung und Sprachgeschichte im Naturraum Westafrikanische Savanne". Wiley-VCH Verlag, Weinheim,196-220.

KIRSCHT H (2001a): Ein Dorf in Nordost-Nigeria. Politische und wirtschaftlichen Transformation der bäuerlichen Kanuri-Gesellschaft. Göttinger Studien zur Ethnologie 6, 345 S.

KIRSCHT H (2001b): Masakwa farming in northeastern Nigeria. Ber. SFB 268 17: 33-60.

KRINGS M (2002): Neusiedler am Tschadsee. In REIKAT A (ed.): Leben in Westafrika, Plexus Verlag, Amorbach, 112-123.

LE BOURGEOIS, T & MERLIER, H. (1993): Adventrop. Les adventices d'Afrique soudano-sahélienne. CIRAD-AC (ed.): Montpellier. 637 pp.

LÖHR D (2001): Masakwa from a linguistic point of view. Ber. SFB 268 17: 85-104.

MORDI, RI, NWAKA, GIC, FOLORUNSO, OA, OHU, JO, BABABE, A, OGUNSOLA, OA, ESU, IE, KAIGAMA, BK, and OMEJE, MU (1991): Report of the soil characterizationof IBSRAM Vertisol; management project sites in northeastern Nigeria. International Board for Soil Research and Management Bangkok, 99 pp.

NEUMANN K (2001): Masakwa farming in the Chad Basin of Northeast Nigeria- Introduction. In KAHLHEBER S & NEUMANN K (eds.): Man and environment in the West African Sahel – an Interdisciplinary Approach. Ber. SFB 268 17: 9-13.

SKORUPINSKI T & FRANKE-SCHARF I (1997): Auswirkungen anthropogener Nutzung auf Böden im nigerianischen Tschadbecken. Luftbildkartierungen von Deflationsschäden im Marte Local Government. Ber. SFB 268 9: 53-66.

THIEMEYER H (1997a): Naturräumliche Voraussetzungen für die Besiedlung des südwestlichen Tschadbeckens im Holozän. Zbl. Geol. Paläont. 1: 77-89.

THIEMEYER H (1997b): Untersuchungen zur spätpleistozänen und holozänen Landschaftsentwicklung im südwestlichen Tschadseebecken (NE-Nigeria). Jenaer Geogr. Schr. 5: 127 S.

THIEMEYER H (2002): Der Tschadsee – Binnenmeer im Herzen Afrikas. In REIKAT A (ed.): Leben in Westafrika, Plexus Verlag, Amorbach, 98-103.

WHITE, F. (1983): The vegetation of Africa. A descriptive memoire to accompany the Unesco/Aetfat/Unso vegetation map of Africa. Unesco Natural Resources Res. 20: 1- 356.

WITTIG R (2005): Echinochloetea colonae classis nova. Etudes flor. veg. Burkina Faso 9, 11-18.

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