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# Flora et Vegetatio Sudano-Sambesica

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# Table of contents | Inhaltsverzeichnis | Table des matières

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# The West African Data and Metadata Repository – a long-term data archive for ecological datasets from West Africa

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**Summary**: Although there is an increasing need for data in ecological studies, many datasets are still lost or not sufficiently visible due to a lack of appropriate data archives. With the West African Data and Metadata Repository, we present a secure long-term archive for a data-poor region allowing detailed documentation by metadata following the EML standard and giving data holders the opportunity to define levels of data access and conditions of use. This article gives an overview of structure, functions and content. The repository is online at the URL http://westafricandata.senckenberg.de.

**Key words**: West Africa , data archiving, ecological data

### Le West African Data and Metadata Repository - une archive de données à long terme pour les ensembles de données écologiques de l'Afrique de l'Ouest

**Résumé:** Bien qu'il existe un besoin croissant de données dans les études écologiques, de nombreux ensembles de données sont encore perdues ou pas suffisamment visibles en raison d'un manque d'archives de données appropriées. Avec le West African Data and Metadata Repository, nous présentons une archive sécurisé à long terme pour une région pauvre en données permettant une documentation détaillée par des métadonnées suivant la norme EML et donnant aux propriétaires de données la possibilité de définir des niveaux de l'accès aux données et les conditions d'utilisation. Cet article donne un aperçu de la structure, des fonctions et du contenu. Le référentiel est en ligne à l'adresse URL http://westafricandata.senckenberg.de.

**Mots clés**: Afrique de l'Ouest, archivage des données, données écologiques

### Das West African Data and Metadata Repository – ein Langzeitdatenarchiv für ökologische Daten aus Westafrika

**Zusammenfassung**: Obwohl zunehmend Daten für ökologische Studien gebraucht werden, gehen noch immer viele Daten verloren oder sind mangels geeigneter Datenarchive nicht sichtbar genug. Mit dem West African Data and Metadata Repository stellen wir ein Langzeitdatenarchiv für eine datenarme Region vor, das eine detaillierte Dokumentation mit Metadaten nach dem EML-Standard erlaubt und Datenhaltern die Möglichkeit gibt, Datenzugangsebenen und Nutzungsbedingungen zu bestimmen. Dieser Artikel gibt einen Überblick zu Struktur, Funktionen und Inhalt. Das Repositorium ist online unter der URL http://westafricandata.senckenberg.de.

**Schlagworte**: ökologische Daten, Datenarchivierung, Westafrika

## 1 Introduction

Plant ecology is continually moving into a direction of ‘big data’. This has become possible by the increasing availability of large collaborative datasets such as species occurrence data from the Global Biodiversity Information Facility (GBIF; Edwards et al. 2000), nomenclature and synonymy datasets like the African Plant Database (Klopper et al. 2006) or plant trait data from TRY (Kattge et al. 2011). Complementary to these large scale organismic data are continental or global environmental datasets for climate, soil, or satellite data and its derivatives, like vegetation indices or tree cover. Increased data availability, common standards and exchange formats have helped to bridge scientific disciplines and tackle urgent environmental issues from local to global scales more efficiently. Consequently, data-driven approaches become increasingly important in ecological and biodiversity studies (Kelling et al. 2009).

While the availability of biodiversity collection data, genetic sequences or environmental grid data have considerably increased, other biological data (which tend to be of a more complex and heterogeneous structure) and their digitization efforts and

availability lag behind. In consequence, this also means that datasets from ecological case studies not fitting easily into the schemes of larger databases are usually stored on scattered desktop computers or storage media instead of being properly archived. Consequently, they are more prone to be lost in the long-term and also less visible to the scientific community. This is even more pronounced in world regions that lack the infrastructure of the industrialized nations.

To improve this situation for ecological datasets from West Africa, we implemented the West African Data and Metadata Repository at the Senckenberg Biodiversity and Climate Research Center as a data warehouse for ecological datasets from West Africa. Long-term support of the database is ensured through integration in the wider structure of the BiK-F Data and Metadata Repository maintained at Senckenberg. This new repository will complement our set of biological databases for West Africa (West African Vegetation: Schmidt et al. 2012; African Plants – a photo guide: Dressler et al. 2014) and give researchers the opportunity of secure long-term archiving and increased visibility of their datasets, while keeping control of data access levels according to their needs.

## 2 Technical structure

The West African Data and Metadata Repository (http://westafricandata.senckenberg.de, see Fig. 1) is based on Metacat (Berkley et al. 2001 ), a data warehouse for ecological and environmental data. Metacat is available under a free public license and allows easy entry and retrieval of data and metadata.

Technically, Metacat is a Java servlet application that runs in conjunction with a relational database such as in our case PostgreSQL and a Web server. Metadata are stored in EML (Ecological Metadata Language, Fegraus et al. 2005), an XML schema, which can be used in a modular and extensible manner to document ecological data. Especially data in tabular formats can be described in detail including row and column information. This way, Metacat guarantees a standardized comprehensive documentation of the data.

Metadata entry and editing is possible via a configurable web form or by using Morpho, a Java-based EML editor, that has explicitly been designed for this purpose (Leinfelder et al. 2011). In addition to the metadata, the data tables themselves as well as further data entities can be optionally included (see Fig.2). This way, data users are able to fully understand the data sets. In addition, semantic web approaches in the ecological sciences are also supported.

Metacat also allows users to define different data access levels for each individual data set, including public (free access to all other users), private (no access to other users) and access restricted to selected registered users of the repository.

By linking Metacat repositories, a parallel search of data in different databases can be facilitated. Metacat is being used by large international data repositories such as the ones from the Knowledge Network for Biocomplexity (KNB), the National Center for Ecological Analysis and Synthesis (NCEAS), the Long-Term Ecological Research Network (LTER) or the Data Observation Network for Earth (DataONE).

## 3 Features

Our local Metacat installation has a specifically adapted interface for the West African Data and Metadata Repository. It consists of a semantic and geographic search tool, a data entry and editing form, and a web map service for visualization. Furthermore, via personal request to the data manager, each inserted dataset can be supplied with a digital object identifier (DOI), as we have registered our Metacat repository with DataCite.

A simple search is available by title, abstract, keywords, persons or by pre-defined frequently used terms of botany, geography and others (see Fig.2). Seven mandatory and seven additional optional EML categories with further subelements are supported by the data entry and editing form (Fig.3). The integrated web map service (WMS) is based on GeoServer and OpenLayers and allows a visualization of the center points or bounding boxes of data sets. A geographic search can be performed by clicking on a point location or by drawing a bounding box into the map (Fig.4).

## 4 Contents

Presently, the repository contains 50 ecological datasets from West Africa. These datasets are thematically diverse, dealing with land degradation, soil parameters, land use and land cover, environmental raster datasets, non-timber forest products, ethnobotanical interview data, species checklists and introduced species (Fig. 5).

Each single dataset is accompanied with metadata. This includes a citation comprising authors, title, document ID and a URL to the complete set of metadata. General information includes an abstract and keywords, upload date and eventually URLs to the data itself. Further sections of the metadata set cover involved parties (dataset owners, curators, contact persons, etc.), geographic coverage, temporal coverage, methods and information on data usage rights and the type of medium the data is distributed with. Datasets described with Morpho include even more detailed information on the data itself.

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**Fig. 1:** Start page of the West African data and Metadata Repository with text-based search functions. The repository can be accessed online via the URL http://westafricandata.senckenberg.de. / Page de démarrage du West African data and Metadata Repository avec des fonctions de recherche textuelle. L'archive peut être consulté en ligne via l'URL http://westafricandata.senckenberg.de.

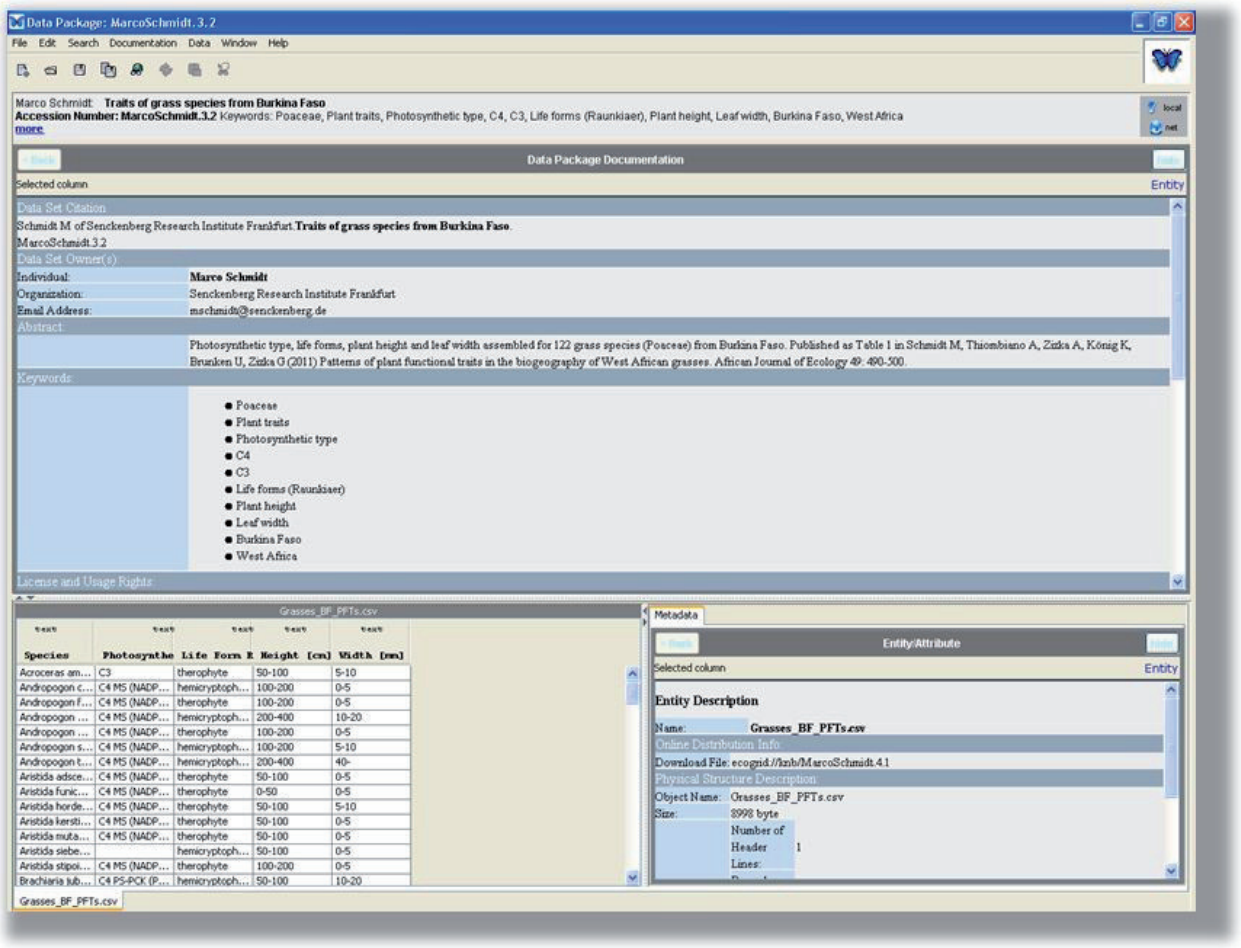


**Fig. 2:** Using Morpho to describe a tabular dataset in detail. / Utilisation de Morpho pour décrire un ensemble de données sous forme de tableau en détail.

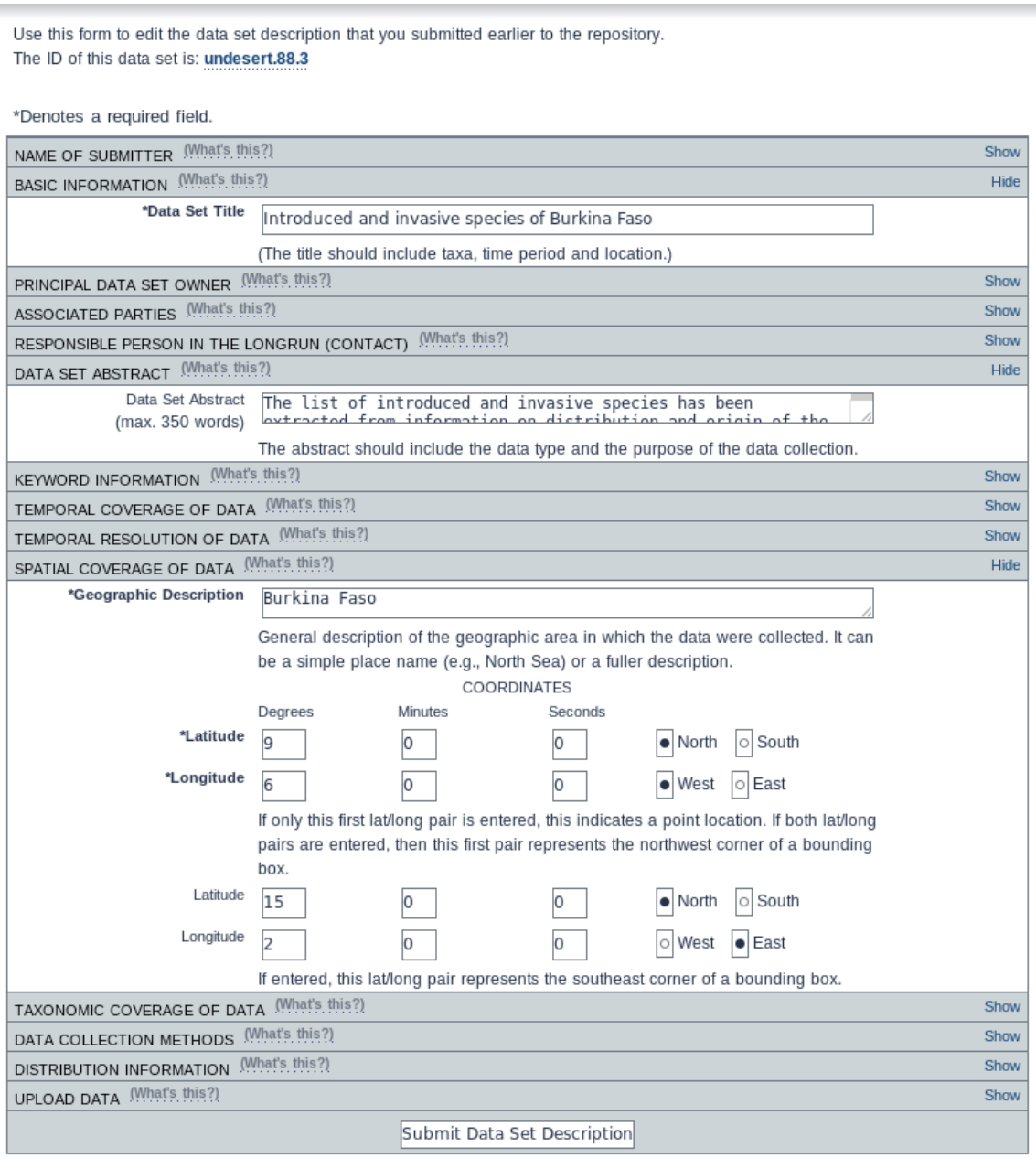


**Fig. 3:** Data entry web form of the West African Data and Metadata Repository. / Forme de web du West African Data and Metadata Repository pour la saisie des données.

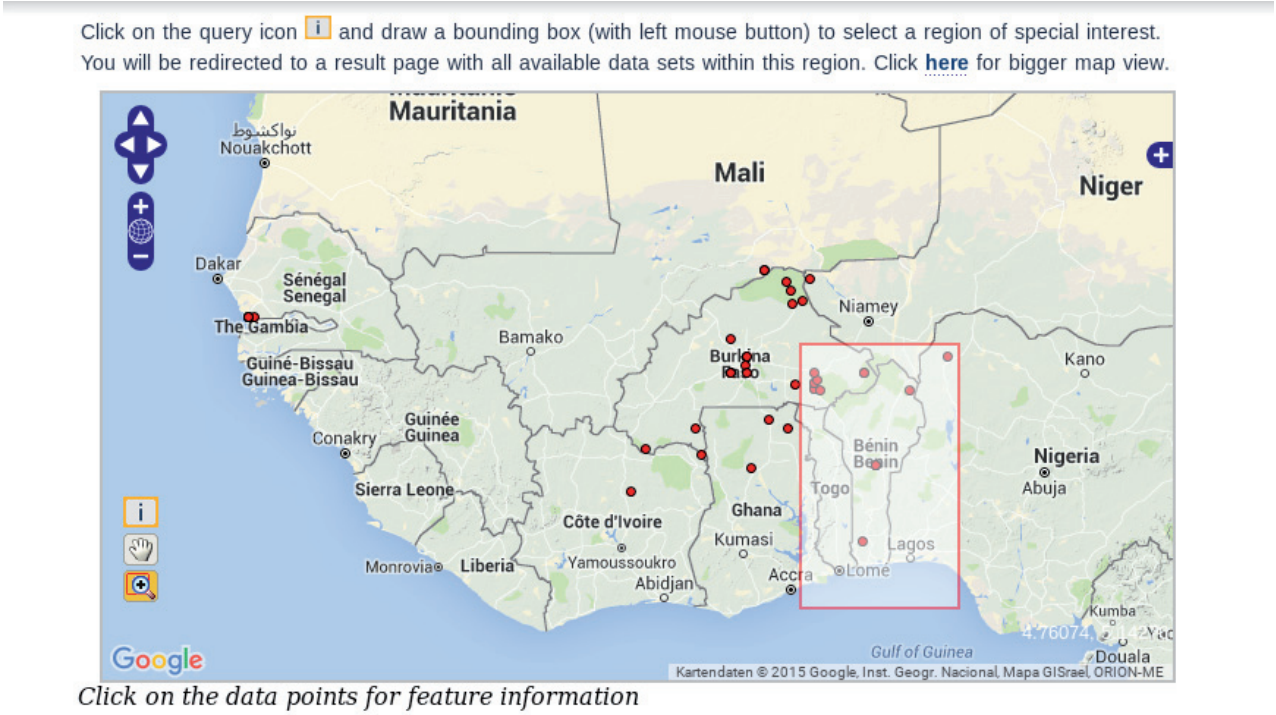


**Fig. 4:** Map view of the West African Data and Metadata repository showing the locations of datasets in red and allowing direct access to the data descriptions by clicking single points or selecting a rectangular area (as shown in this screenshot around Benin). / Carte interactive du West African Data and Metadata Repository montrant les emplacements des ensembles de données en points rouges et permettant accès direct aux descriptions de données en cliquant sur les points ou en sélectionnant une zone rectangulaire (comme le montre cette capture d'écran).

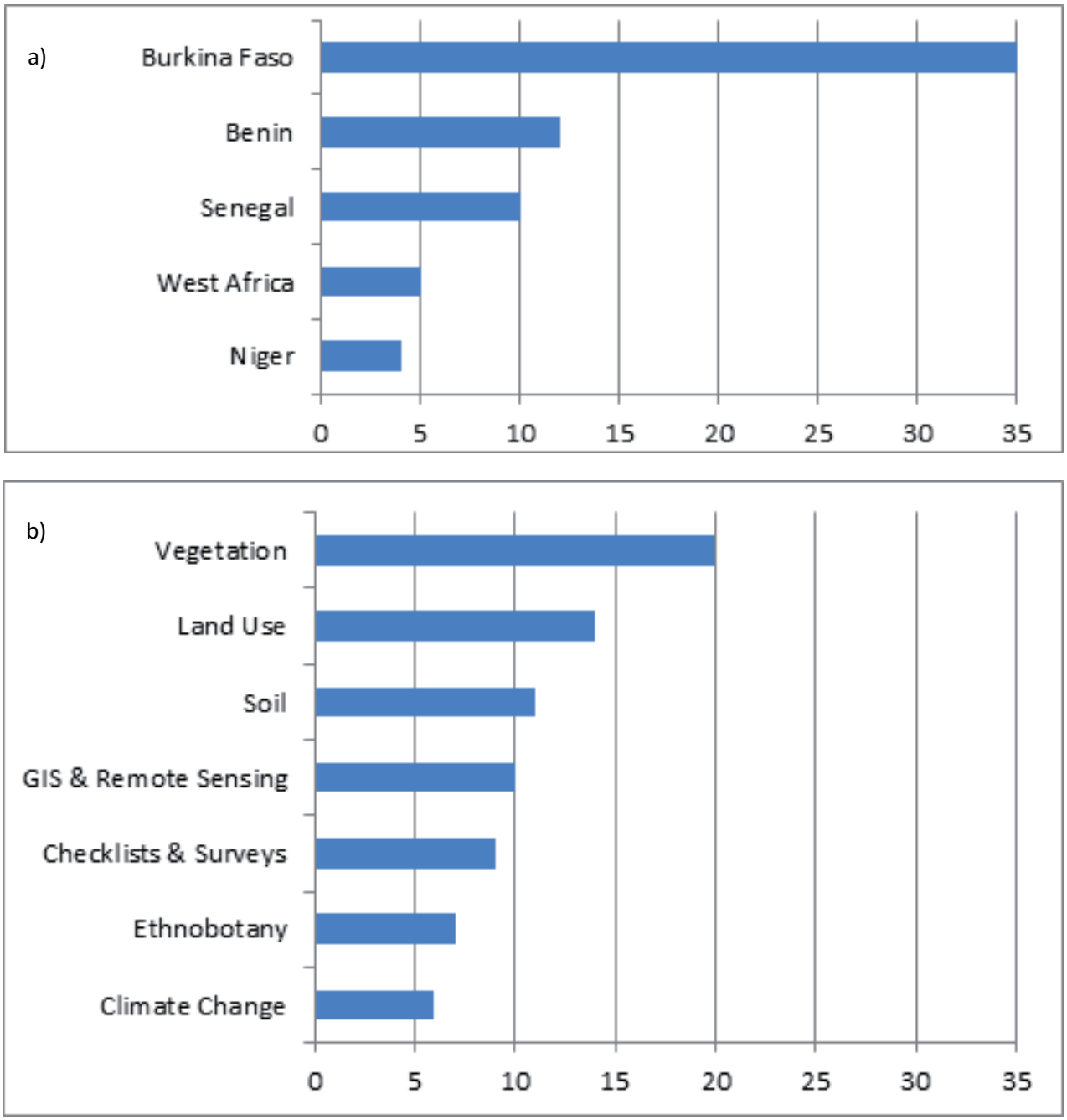


**Fig. 5:** Number of datasets summarized (a) by individual countries or West Africa as a region, and (b) by thematic fields. As a single dataset may cover several countries and themes, the sum exceeds the total number of datasets. / Nombre d'ensembles de données résumées (a) par des pays individuels ou l'Afrique de l'Ouest en tant que région, et (b) par des champs thématiques. Comme un seul ensemble de données peut couvrir plusieurs pays et thèmes, la somme dépasse le nombre total des ensembles de données.

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# Substitution of the most important and declining wild food species in south-east Burkina Faso

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**Summary**: Wild plant species are important nutritious supplements to otherwise nutrient poor diets of rural populations in West Africa. Consequently, a decline of wild food species has a direct negative impact on the nutritional status of local households. In this study, we firstly investigated the preferred wild food species in south-east Burkina Faso, their perceived change in abundance as well as their contribution to wild food income. Secondly, we studied how these species might be substituted in times of species shortfall. Thirdly, we investigated the impact of socio-economic variables on the substitution choice. We conducted 155 household interviews in two villages and found 21 wild food species. With a contribution of almost 70% to wild food income, *Vitellaria paradoxa* and *Parkia biglobosa* were economically most important. All species were considered declining to some degree. The wide range of cited substitutes for the ten most important wild food species indicates a great knowledge on alternative plant species in the area. For the majority, the substitution choice did not depend on socio-economic characteristics. Cited as surrogate for several important wild food species, the native tree *Balanites aegyptiaca* was the most important substitute species. Many valued wild food species were substituted with other highly valued wild food species and therefore the decline of one species can lead to a shortfall of another substitute. Thus, even though our results suggest that people are able to counteract the decrease or absence of wild food species, growing decline of one species would concurrently increase the pressure on other native food species.

**Key words**: species decline, wild food, income, NTFPs, substitutes

## Substitution des plus importantes et décroissantes espèces alimentaires sauvages au Sud-Est du Burkina Faso

**Résumé**: Des espèces de plantes sauvages constituent des compléments nutritionnels importants des régimes alimentaires pauvres en micronutriments des populations rurales en Afrique de l'Ouest. Par conséquent, le déclin des espèces alimentaires sauvages a un impact négatif direct sur la nutrition des ménages locaux. Dans cette étude, nous avons premièrement investigués les espèces alimentaires sauvages préférées dans le sud-est du Burkina Faso, leur changement perçu en abondance ainsi que leur contribution au revenu alimentaire sauvage. Deuxièmement, nous avons étudié comment ces espèces pourraient être substituées en période de pénurie des espèces. Troisièmement, nous avons examiné l'impact des variables socio-économiques sur le choix de substitution. En réalisant 155 interviews auprès des ménages dans deux villages, nous avons trouvé 21 espèces alimentaires sauvages. Avec une contribution d'environ 70% au revenu alimentaire sauvage, *Vitellaria paradoxa* et *Parkia biglobosa* sont économiquement les espèces les plus importantes. Toutes les espèces sont été considérées comme étant en déclin dans une certaine mesure. La vaste gamme de substituts cités pour les dix espèces les plus importantes indique une grande connaissance sur les espèces végétales alternatives dans la zone. Pour la plupart des plus importantes espèces alimentaires sauvages, le choix de substitution ne dépend pas des caractéristiques socio-économiques. Cité comme représentant pour plusieurs espèces importantes alimentaires sauvages, l'arbre local *Balanites aegyptiaca* est la plus importante espèce de substitut. De nombreuses espèces alimentaires sauvages évaluées sont substitués par d'autres espèces alimentaires sauvages à grande valeur et dont le déclin d'une espèce peut conduire à un déficit d'un autre substitut. Ainsi, même si nos résultats révèlent que les populations sont potentiellement capables de contrecarrer la diminution ou l'absence des espèces alimentaires sauvages, le déclin croissant d'une seule espèce pourraient simultanément augmenter la pression sur les autres espèces alimentaires locales.

**Mots clés**: PFNLx, déclin d'espèce revenu, aliment sauvage, substituts

## Substituierung der wichtigsten und zurückgehenden essbaren Wildpflanzen in Südost Burkina Faso

**Zusammenfassung**: Essbare Wildpflanzen stellen wichtige Nahrungsergänzungen, zu einer ansonsten nährstoffarmen Ernährung ländlicher Bevölkerung in West Afrika, dar. Aus diesem Grund hat der Rückgang von essbaren Wildpflanzen direkte negative Auswirkungen auf den Nährstoffhaushalt lokaler Haushalte. In dieser Studie dokumentierten wir erstens die bevorzugten essbaren Wildpflanzen in Südost Burkina Faso, ihre wahrgenommene Abundanzveränderung und ihren Anteil am essbaren Wildpflanzen-Einkommen. Wir untersuchten zweitens die Substituierung dieser Arten in Zeiten von Artenknappheit und drittens den Einfluss von sozio-ökonomischen Variablen auf die Auswahl der Substitute. Mit 155 Haushaltsbefragungen in zwei Dörfern erhielten wir insgesamt 21 genutzte essbare Wildpflanzen. Mit einem Beitrag von rund 70% zum essbaren

Wildpflanzen-Einkommen waren *Vitellaria paradoxa* und *Parkia biglobosa* ökonomisch die wichtigsten Arten. Alle Arten wurden als mehr oder weniger zurückgehend eingestuft. Die hohe Anzahl genannter Substitute für die zehn wichtigsten essbaren Wildpflanzen zeigt ein umfassendes Wissen bezüglich alternativer Wildpflanzen in dem Untersuchungsgebiet. Die Substitutauswahl ist für die Mehrheit der essbaren Wildpflanzen nicht abhängig von sozio-ökonomischen Merkmalen. Der heimische Baum *Balanites aegyptiaca* wurde für mehrere essbare Wildpflanzen als Substitut genannt und war damit die wichtigste Substitutart. Viele der bevorzugten essbaren Wildpflanzen wurden mit anderen bevorzugten essbaren Wildpflanzen substituiert. Der Rückgang einer Art kann somit zum Wegfall eines anderen Substitutes führen. Obwohl unsere Ergebnisse suggerieren, dass die Menschen dem Rückgang oder Fehlen von essbaren Wildpflanzen entgegenwirken können, würde ein zunehmender Rückgang einer Art gleichzeitig den Druck auf andere heimische Wildpflanzen erhöhen.

**Schlagworte**: Artenrückgang, Einkommen, Nichtholzprodukte, Substitute, essbare Wildpflanzen

## 1 Introduction

In West Africa, livelihoods of rural people are highly dependent on non-timber forest product (NTFP)-providing plant species for subsistence and cash income (Agrawal et al. 2013). NTFPs include all products other than timber derived from forests and agroforestry systems, such as fruits, nuts, vegetables, fish, game, medicinal plants, bark, gum, leaves, grasses and small wood products like firewood and chew-sticks (Belcher 2003; CIFOR 2011). They serve i.e. as source for firewood, food, medicine, construction and fodder and therefore provide a safety net in times of income shortages trough i.e. crop shortfalls (cf. Malleson et al. 2014; Shackleton & Pandey 2014). The extraction of NTFPs is particularly attractive for the very poor since NTFPs are open or semi-open access resources that do not require expensive equipment for harvesting (Angelsen and Wunder 2003). In northern Benin, Heubach et al. (2013) identified 90 and Vodouhê et al. (2009) 76 plant species that are locally used for various purposes. In the Sahel of Burkina Faso, Lykke et al. (2004) found 56 woody species of multipurpose value to rural livelihoods. The food provision of those species is particularly important to complement diets in quantity and to add minerals and vitamins to a generally monotonous and nutrient poor diet. For this purpose, edible fruits, flowers, seeds and leaves are collected from parkland trees in fallows and fields and from woody species in woodlands.

A shortfall of NTFPs can severely affect household livelihoods in terms of food security, energy supply, medical care, animal husbandry, and financial means. Short-term NTFP shortage might be caused by low rainfall and/or depleted stocks before the next harvest season. However, human population growth increases the pressure on cultivated land in the long term. It leads to expanded agricultural land and a shortening of fallow stages, causing species loss due to lacking regeneration of the natural vegetation. Several studies in West Africa anticipate serious shifts in climatic conditions and land use patterns which are likely to affect water resources and soil fertility (Cooper et al. 2008; Sala et al. 2000) and thus, the provision of non-timber forest products (NTFPs). A recent investigation conducted in Benin, projected a decrease in regional occurrence and, thus, obtained economic returns, up to 50% in 2050 for key NTFP providing tree species (Heubes et al. 2012).

Since Burkina Faso belongs to the poorest countries on earth (UNDP 2014), coping with these predicted negative changes will be a major challenge to the rural poor. It is therefore of particular importance to investigate which species are particularly declining, how they contribute to household income and whether and how a projected decrease could be counteracted to mitigate the socio-economic consequences.

As the coping capacity of households is particularly conditioned by their socio-economic characteristics (Pattanayak & Sills 2001; Turner et al. 2003) it is furthermore crucial to investigate whether all households have similar strategies to replace wild food species or whether they differ with regard to to social and spatial differentiations (e.g. village, ethnicity, household income), in order to develop management strategies that are reliable for a specific region. For example, investigating valuation and use preferences of wild plant species in Benin and Burkina Faso, Segnon & Achigan-Dako (2014) and Zizka et al. (2015) showed that location and ethnicity have an effect. Further, in terms of NTFP income Kalaba et al. (2013) showed that a household's property level determines coping opportunities: poorer households enhanced their engagement in NTFP extraction to cope with shocks considerably stronger than wealthier households.

Understanding local systems of supply and dependencies is crucial to support local decision-makers in enhancing rural communities' adaptive capacities to environmental change. In West Africa, a number of current studies investigated plant species valuation, use and economic contribution, but there is a need to study compensations and coping strategies in case of species' shortfall.

Consequently, we focused on the substitution of wild food species. In a first step, we identified the most valued wild food species, and since their contribution to daily diet is their most important usage, we focused our analysis accordingly. Secondly, the observed species decline and its contribution to wild food income was studied. Thirdly, we identified the substitutes used by rural households to cope with a seasonal/temporary absence of NTFPs.

In our study, we thus seek to answer the following questions:

1. What are the most important wild food species and how do they contribute to household income?
2. Which species are observed to be declining?
3. How are these wild food species substituted in times of species shortfall?
4. Does the substitution preference depend on socio-economic characteristics?

## 2 Methods

### 2.1 Study villages

The investigations were conducted in the north Sudanian zone in south-east Burkina Faso. We selected two study

villages (Nagré and Kompienbiga) lying 70 km apart (Fig. 1). These villages were chosen due to their similar characteristics in terms of population size (around 1000-1300 households), distance to the next urban centre (30 km to Fada N'Gourma and 10 km to Pama) and the constitution of main ethnic groups. Furthermore, the availability of a school, hospital, piped water and a local market, but a lack of electricity, is common to both villages.

Kompienbiga is situated in a more humid zone than Nagré. Thus, we obtained information from two climatically differing areas.

The vegetation is composed of different savanna types, woodland, tree, shrub and grass savanna. The typical farming system is characterised by alternating cycles of cultivation and fallow periods, managed by subsistence farmers. Useful tree species are spared from field clearing. Agriculture and extensive livestock breeding (e.g., cattle, goat, sheep and chicken) are the main income sources in the region.

### 2.2 Ethnic groups

The three main ethnic groups located in the study area are the two agriculturalist societies, Gourmantché and Mossi and the seminomadic pastoralists, Fulani. The Gourmantché are the dominant, autochthon people in the area. The Mossi, who are the most dominant ethnic group in the country originally living in the centre of Burkina Faso, migrated to the study area (CIA 2009). The Fulani also migrated to the area from the countries' northern part.

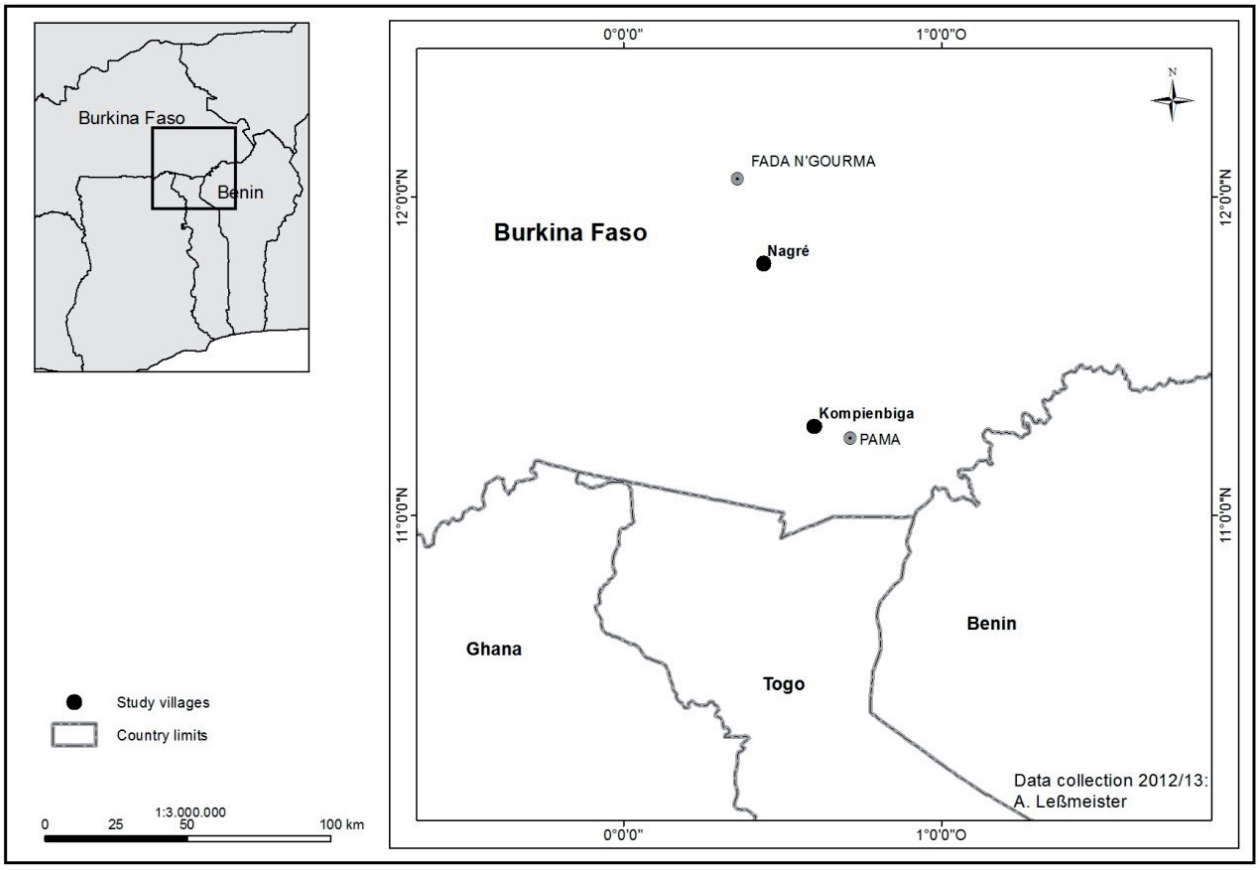


**Fig. 1 : Location of the study villages in south-east Burkina Faso / Localisation des villages de l'étude au Sud-est du Burkina Faso.**

### 2.3 Data collection and analysis

In our study, we followed the interview approach and methods as implemented in northern Benin by Heubach et al. (2011). We conducted a total of 155 structured household surveys using both closed and open questions at the end of the harvesting period between November 2012 and April 2013. In both villages, a minimum of 25 interviews within each ethnic group was considered. Households were chosen by stratified random methods according to their ethnicity. Interviews were conducted separately with the household head (always a man) and his first wife (households are often polygamous). Women cited the most valued wild food species with the plant parts used (i.e. flowers, fruit, leaves) and the form of use (i.e. raw, sauce, drink). Each species mentioned was ranked according to a change category (1 = increasing, 0 = no change, -1 = decreasing, -2 = very decreasing) and reasons for the species decline were asked using open questions. To calculate income share values of wild food, women additionally provided information on the collection and consumption of the cited wild food species in their household within the year 2012 as well as on prices at the local market. Subsequently, they were asked to report substitutes for the wild food species when they are seasonally/

temporary unavailable. Each woman mentioned one substitute for one wild food species. Aiming at relating substitution of wild food species to socio-economic characteristics, we additionally collected data regarding household income, age and education of the household head and farmland size owned. This information was provided by the household head. Furthermore, we conducted market interviews at village markets to double check and complement prices. To ensure comparability between households of different sizes and compositions we conducted an income adjustment. We applied an OECD modified equivalence scale considering types of household members (men, women, children) reflecting the nutrition need and the number of household members (household size) (Deaton 1982). The result is an adjusted income per adult equivalent unit (aeu) allowing comparability.

For species mentioned by less than 5% of the respondents, we did not include change and income share values. The interviews were conducted in local languages with an interpreter.

To study whether the choice in substitution was related to socio-economic variables, the mentioned substitutes were tested against the following variables using a chi-square test: Village origin (Nagré; Kompienbiga), ethnicity (Gourmantché; Mossi; Fulani), age (4 categories, <35, 36-45, 46-55, >56), education (yes; no), income groups (3 terciles – 'poor', 'medium' and 'less poor'), and farmland size (< 4 ha; > 4 ha).

The average household size of both studied villages was composed of seven to nine members and the household heads were, on average, in their mid-forties. For all ethnic groups, the education level was very low. The agriculturalists Gourmantché and Mossi owned more farmland than the pastoralists (Fulani). Household income was higher in the village Nagré for all ethnic groups compared to Kompienbiga. The autochthonous Gourmantché in Nagré had the highest household income.

## 3 Results

### 3.1 Wild food species importance

Respondents mentioned 21 wild food species, 20 woody and one herbaceous species (*Corchorus olitorius*), collected for subsistence consumption (Table 1). Only one plant part, i.e. the fruits, leaves, seeds or flowers, was used of the majority of the stated plant species as food supply. For three species (*Vitellaria paradoxa*, *Adansonia digitata*, *Annona senegalensis*) two plant parts were used (Table 1). *Vitellaria paradoxa* was the most important wild food species as it was mentioned by nearly all respondents. With a contribution of 43% to the households' wild food income *V. paradoxa* was also the most important economic food species. *Lannea microcarpa* was the second most important wild food species in terms of citations, but only gave a very little share to households' wild food income. All other species were only stated by less than 50% of the respondents. Even though *Parkia biglobosa* was only mentioned by 45% of the respondent, it was economically important as it contributed with a high share (26%) to households' wild food income. Five species (*Corchorus olitorius*, *Piliostigma reticulatum*, *Piliostigma thonningii*, *Sclerocarya birrea*, *Vitex doniana*) were only mentioned by one informant.

### 3.2 Species decline

According to the respondents, all wild food species were considered declining, but the degree differed (Table 1). *Vitellaria paradoxa*, *Parkia biglobosa*, *Balanites aegyptiaca* were classified as very strongly declining species with a value between 1,5 and 2.

*Lannea microcarpa*, *Ziziphus mauritiana*, *Detarium microcarpum*, *Diospyros mespiliformis*, *Adansonia digitata*, *Gardenia erubescens*, *Ximenia americana* were classified as strong declining (between 1,5 and 1,7). *Tamarindus indica*, *Bombax costatum* and *Annona senegalensis* were rated as declining between 1.1 and 1.4. The free cited reasons for decline were relatively homogenous. The most cited reason for all species was "removal of seedlings and saplings", followed by "excessive cut" and "shortage of rainfall".

### 3.3 Substitutes

For substitute analysis, we only considered species that were cited at least by 20 respondents as useful food species, giving a total of 10 species (see Table 1). Interviews revealed that the number of substitutes differed widely between the 10 studied wild food species. While the fruits of *Lannea microcarpa* and the seeds of *Parkia biglobosa* could be substituted by 14 other products, the calyxes of *Bombax costatum* were replaceable by only three products (Fig. 2). The other seven studied wild food species were substituted by 8 to 11 products. For all target species, one to three substitutes were mentioned by a high proportion of interviewed women, while the other substitutes were mentioned by very few respondents.

Very few respondents (< 10%) stated that they had no substitution for the 10 studied woody species. For all studied species, native woody species were the most cited substitutes (in total 21 species), while wild herbaceous (1 species) and cultivated plants (2 species) were very rarely mentioned (Fig. 2). Many woody species were mentioned several times as substitutes. The fruits of *Balanites aegyptiaca* were the most important substitutes for four studied species. The substitutes for each of the 10 most important woody species are described in detail in the following:

Interviewed women reported to replace the fruits of *Vitellaria paradoxa* by fruits of 10 native woody species (Fig. 2). By far the most cited substitutes were the fruits of *L. microcarpa*, followed by the fruits of *Diospyros mespiliformis*. Correspondingly, the fruits of *Vitellaria paradoxa* were the most cited substitutes for the fruits of *L. microcarpa*. The fruits of *D. mespiliformis* and *Ziziphus mauritiana* were also frequently cited as substitutes of *L. microcarpa*, while the other 11 cited substitutes (all woody species) were mentioned by very few respondents.

The seeds/ fruits of *P. biglobosa* and *Z. mauritiana* were substituted by 14 and 11 products, respectively (all woody species). For both species, the fruits of *B. aegyptiaca* were the most important substitutes. The fruits of *Z. mauritiana*

**Table 1:** **List of all cited wild food species by 155 respondents, percentage citation of species, used plant part, form of use and estimated change of the species (0 = no decline, -1 = decline, - 2 = strong decline). / Liste de toutes les espèces alimentaires sauvages cités by 155 répondants, pourcentage de citation des espèces, partie de la plante utilisée, forme d'utilisation et variation estimative des espèces (0 = pas de déclin, -1 = déclin, - 2 = fort déclin)**

| No. | Species | Number of citations in % | Plant part | Form of use | Change | Wild food income per aeu* in % |
|---|---|---|---|---|---|---|
| 1 | *Vittelaria paradoxa* | 97 | fruit | raw | -1.85 | 43 |
| | | | seeds | cooking oil | | |
| 2 | *Lannea microcarpa* | 79 | fruit | raw | -1.53 | 3 |
| 3 | *Parkia biglobosa* | 45 | seeds | sauce | -1.73 | 26 |
| 4 | *Ziziphus mauritiana* | 44 | fruit | raw | -1.56 | 1 |
| 5 | *Tamarindus indica* | 38 | fruit | sauce, drink, raw | -1.36 | 7 |
| 6 | *Balanites aegyptiaca* | 34 | fruit | raw | -1.91 | 1 |
| 7 | *Detarium microcarpum* | 27 | fruit | raw, cooked | -1.65 | 1 |
| 8 | *Diospyros mespiliformis* | 21 | fruit | raw | -1.81 | 1 |
| 9 | *Adansonia digitata* | 18 | leaves | sauce | -1.51 | 7 |
| | | | fruit | raw, drink, sauce | | |
| 10 | *Bombax costatum* | 14 | calyx | sauce | -1.33 | 9 |
| 11 | *Gardenia erubescens* | 6 | fruit | raw | -1.54 | 0.1 |
| 12 | *Annona senegalensis* | 5 | flower | sauce | -1.10 | 0.5 |
| | | | fruit | raw | | |
| 13 | *Ximenia americana* | 5 | fruit | raw | -1.58 | 0.1 |
| 14 | *Strychnos spinosa* | 4 | leaves | sauce | NA | NA |
| 15 | *Vitex simplicifolia* | 3 | fruit | raw | NA | NA |
| 16 | *Sarcocephalus latifolius* | 1 | fruit | raw | NA | NA |
| 17 | *Corchorus olitorius* | 1 | leaves | sauce | NA | NA |
| 18 | *Piliostigma reticulatum* | 1 | leaves | sauce | NA | NA |
| 19 | *Piliostigma thonningii* | 1 | leaves | sauce | NA | NA |
| 20 | *Sclerocarya birrea* | 1 | fruit | raw | NA | NA |
| 21 | *Vitex doniana* | 1 | fruit | raw | NA | NA |

* aeu: adult equivalent unit (explanation see 2.3) / aeu: unité équivalente adulte (explication voir 2.3)

were mostly cited as substitutes for the fruits of *B. aegyptiaca*. There were 11 woody species used as substitutes for *B. aegyptiaca*.

For *Tamarindus indica*, women reported 8 products as substitutes. The exotic lemon tree (*Citrus × limon*) and the fruits of the local shrub species *Piliostigma reticulatum* and *P. thonningii* were the most important substitutes.

The fruits of *Detarium microcarpum* and *D. mespiliformis* could be substituted by 11 and 9 products, respectively (all woody species). For both species, the fruits of *B. aegyptiaca* were the most important substitutes. To replace the fruits of *D. microcarpum* and *D. mespiliformis* the fruits of *D. mespiliformis* and *Z. mauritiana*, respectively, were also favored.

The fruits and leaves of *Adansonia digitata* could be substituted by 11 products (9 woody species, one herbaceous species, and one cultivated plant). More than half of the respondents declared that the leaves of *A. digitata* could be substituted by the calyxes of *B. costatum*. The seeds of *P. biglobosa* and the leaves of the herb *Corchorus olitorius* were the second and third most important substitutes.

The calyxes of *B. costatum* were replaceable by only 3 products (2 woody species, 1 cultivated plant). Most respondents stated that they use the leaves of *A. digitata* as substitutes of the calyxes of *B. costatum*. The cultivated vegetable lady fingers (*Abelmoschus esculentus*) was the second most cited substitute.

### 3.3.1 Relation of substitution choice and socio-economic-characteristics

For most of the ten wild food species the tested variables (ethnicity, village, age, education, income and farmland size) did not show an influence on the choice in substitution. However, village had a significant influence on the substitution of three species and ethnicity, income, and farmland size of one studied species (Fig. 3). In contrast, age and education did not influence the choice in substitution of the 10 studied woody species.

The substitution of the seeds from *Parkia biglobosa* differed significantly between the three ethnic groups ($X^2$= 33.5, p = 0.044). The Gourmantché (13 substitutes) mentioned twice as many substitutes as the Mossi (7 substitutes) and Fulani (6 substitutes). For the Gourmantché, the fruits of *Vitellaria*

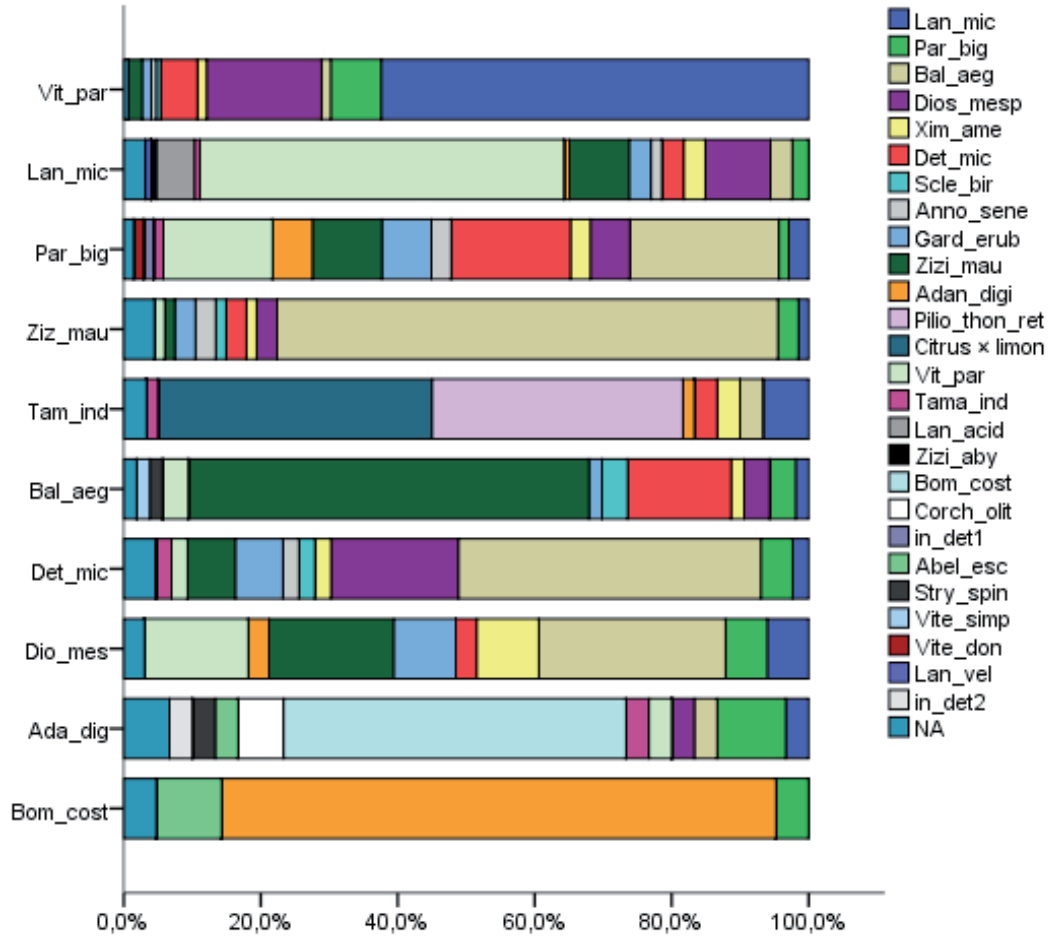


**Fig. 2: Dietary substitutes for the fruits of the 10 most important wild food species / Substituts nutritionnels pour les fruits des 10 plus importantes espèces alimentaires sauvages. Vit_par** = *Vitellaria paradoxa*, **Lan_mic** = *Lannea microcarpa*, **Par_big** = *Parkia biglobosa*, **Ziz_mau** = *Ziziphus mauritiana*, **Tam_ind** = *Tamarindus indica*, **Bal_aeg** = *Balanites aegyptiaca*, **Det_mic** = *Detarium microcarpum*, **Dio_mes** = *Diospyros mespiliformis*, **Ada_dig** = *Adansonia digitata*, **Bom_cost** = *Bombax costatum*, **Xim_ame** = *Ximenia americana*, **Scle_bir** = *Scleocarya birrea*, **Anno_sene** = *Annona senegalensis*, **Gard_erub** = *Gardenia erubescens*, **Pilio_thon_ret** = *Piliostigma* **sp., Lan_acid** = *Lannea acida*, **Zizi_aby** = *Ziziphus abyssinica*, **Corch_oli** = *Corchorus olitorius*, **Abel_esc** = *Abelmoschus esculentus*, **Stry_spin** = *Strychnos spinose*, **Vit_simp** = *Vitex simplicifolia*, **Vit_don** = *Vitex doniana*, **Lan_vel** = *Lannea velutina*, **NA = not available / non disponible, in_det = species not identified / espèce non identifiée.**

*paradoxa* were the most important substitutes, while fruits of *Detarium microcarpum* and *Balanites aegyptiaca* were the most important substitutes for the Mossi and Fulani, respectively.

Income significantly influenced the choice in substitution of fruits from *V. paradoxa* ($X^2$= 29.0, p= 0.049). The poor and medium income group cited more substitutes in total (6 and 8, respectively) than the less poor income group (4). The fruits of *Lannea microcarpa* were the most important substitutes for all three income groups. The fruits of *Diospyros mespiliformis* were the second most important substitutes for the poor and medium income group, while the seeds of *P. biglobosa* were the second most cited substitute of the less poor group.

Village origin significantly influenced the choice in substitution of fruits from *V. paradoxa* ($X^2$= 42.6, p = 0.000), *Tamarindus indica* ($X^2$= 15.1, p = 0.035), and *L. microcarpa* ($X^2$= 33.5, p = 0.044). People from the southern village Kompienbiga knew twice as many substitutes (10) for the fruits of *V. paradoxa* than those of the northern village Nagré (5). Contrary to *V. paradoxa*, people from Nagré knew more substitutes of *T. indica* (7) and *L. microcarpa* (10) than people from the village Kompienbiga (5 and 9, respectively). While *Citrus* × *limon* was the main substitute of *T. indica* in Nagré, people from Kompienbiga mostly cited the fruits of the native shrubs *Piliostigma reticulatum* and *P. thonningii* as substitute.

Farmland size only significantly influenced the substitution choice of the fruits from *L. microcarpa*. People holding more farmland for cultivation (> 4 ha) more often cited the fruits of *V. paradoxa* as substitutes than people owing less farmland (< 4 ha).

## 4 Discussion

### 4.1 Wild food species

The ten wild food species identified as most important for rural communities in south-east Burkina Faso have also been found most useful in other regions of West Africa,

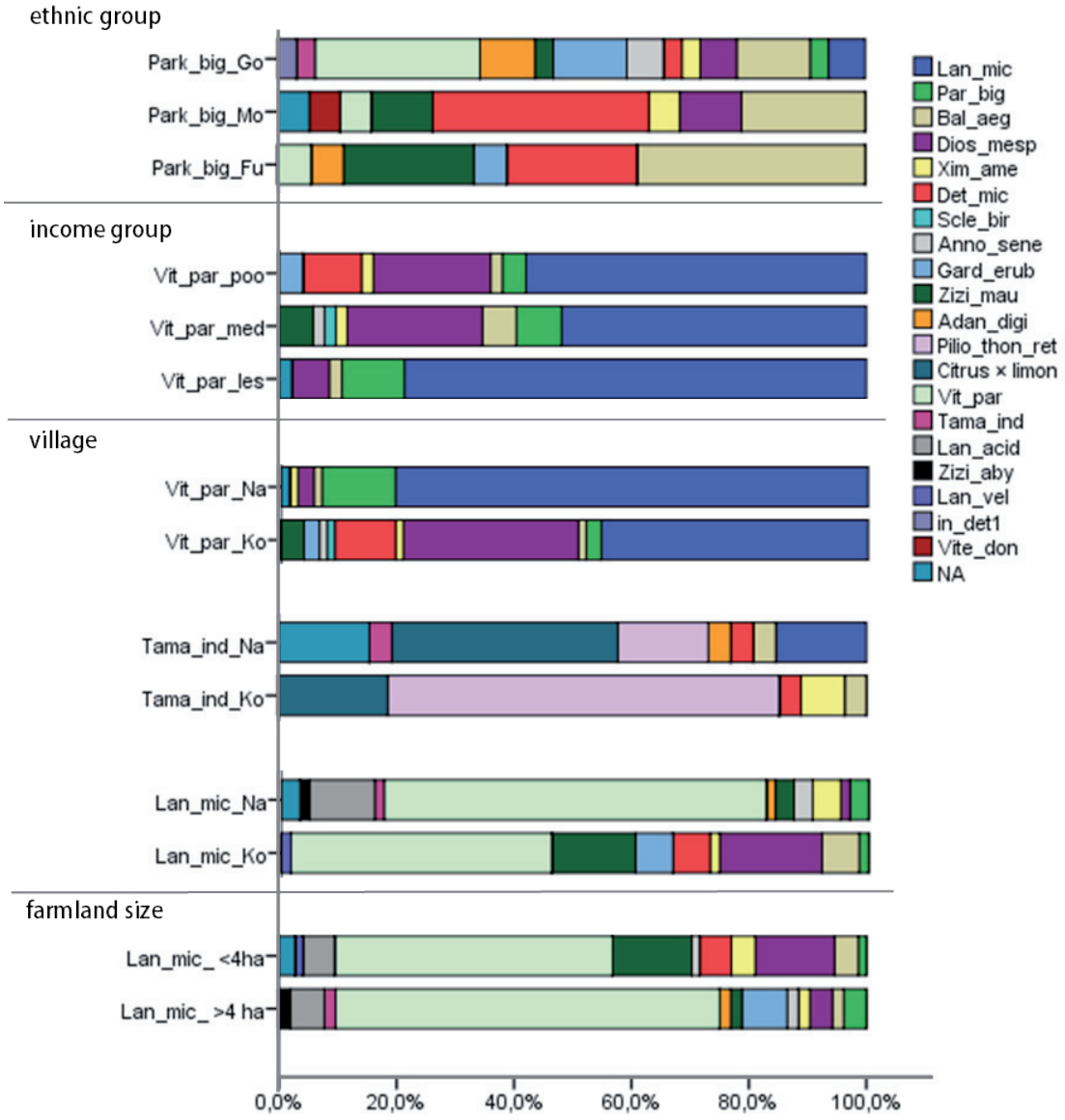


**Fig. 3: Differences in substitution of wild food species between ethnic and income groups, villages and farmland size. / Différences dans la substitution des espèces alimentaires sauvages entre groupes ethnique et de revenu, les villages et la taille des terres agricoles. Vit_par =***Vitellaria paradoxa***, Lan_mic =** *Lannea microcarpa*, **Park_big =** *Parkia biglobosa*, **Tam_ind =** *Tamarindus indica*, **Ziz_mau =** *Ziziphus mauritiana*, **Bal_aeg =** *Balanites aegyptiaca*, **Det_mic =** *Detarium microcarpum*, **Dios_mesp =** *Diospyros mespiliformis*, **Adan_digi =** *Adansonia digitata*, **Xim_ame =** *Ximenia americana*, **Scle_bir =** *Scleocarya birrea*, **Anno_sene =** *Annona senegalensis*, **Gard_erub =** *Gardenia erubescens*, **Pilio_thon_ret=** *Piliostigma* **sp., Lan_acid =** *Lannea acida*, **Zizi_aby =** *Ziziphus abyssinica*, **Vite_don =** *Vitex doniana*, **Lan_vel =** *Lannea velutina*, **Go= Gourmantché, Mo= Mossi, Fu= Fulani, poo= poor / pauvres, med= medium / moyen, les= less poor / moins pauvres, Na= Nagré, Ko=Kompienbiga, <4ha= farmland size less than 4 ha/ taille de terres agricoles moins de 4 ha, >4ha= farmland size more than 4 ha/ taille des terres agricoles de plus de 4 ha, NA = not available / non disponible, in_det= species not identified / espèces non identifiées.**

showing their supra-regional importance. For instance, Sop et al. (2012) found six, Lykke et al. (2004) and Heubach et al. (2013) five of our ten species as the most useful wild food species in the Sahelian and Soudanien zones. In all studies, woody species are the best known, valued and used wild food supplier, while similarly to our study, herbs are of minor importance. In northern Benin, *Vitellaria paradoxa* and *Parkia biglobosa* are the two most valued wild food use species (Heubach et al. 2013). Furthermore, the total number of 29 identified useful wild food species is in accordance with our findings.

Of the ten most useful food species, the fruits were by far the most valuable plant parts. Fruits from wild woody plants are inter alia especially important as supplement for crops, due to their maturity outside the crop harvest season (Lykke et al. 2004). The three most valued wild food species (*Vitellaria paradoxa*, *Lannea microcarpa*, *Parkia biglobosa*) as well as *Adansonia digitata* and partly also *Tamarindus indica* and *Bombox costatum* are typical parkland trees, left on the fields during field clearings (Haarmeyer et al. 2013; Schreckenberg 1999; Schumann et al. 2012).

The by far most important wild food species *V. paradoxa* has been investigated in various studies. *Vitellaria paradoxa* seeds supply important cooking oil, commonly known as shea butter, for local livelihoods. It serves as the most important source of fat for rural people. Additionally, the fruit can be eaten raw. The very high share of *V. paradoxa* to wild food income in our study was similarly found

by Pouliot (2012), with *V. paradoxa* contributing 12% to total household income in south western Burkina Faso. The fruits of the second most mentioned wild food species *L. microcarpa*, commonly known as african grape or wild grape, are eaten raw or produced as juice (Haarmeyer et al. 2013). Since this use is less important to the local cooking (compared to *V. paradoxa*), they only contributed with a small share of 3% to wild food income, which could additionally be due to a considerably lower price on local markets as well as on lower total amounts harvested. *Parkia biglobosa*, known as the African locust bean tree, contributed considerably to wild food income of local households with 26%. Its' fermented seeds, called soumbala, are an essential and typical product for cooking sauces in the region. Due to its' high protein and fat content, soumbala is an important supplement to staple foods in rural areas of West Africa (Kronborg et al. 2014). Other species that contributed considerably to alimentation and wild food income of rural livelihoods were *T. indica*, *A. digitata* and *B. costatum*. The tamarind (*T. indica*) and the baobab (*A. digitata*) are used for sauces, porridge, as drinks and both contain considerable amounts of proteins and vitamin C (Gebauer et al. 2002; Jama et al. 2008). *B. costatum*, the silk cotton tree, is highly valued for the local cuisine. The calyxes were used to prepare a highly valued sauce. Even though it was less often mentioned as important wild food species its contribution to wild food income was appreciable.

Compared to studies with predefined species lists (Lykke et al. 2004) our study revealed a considerably lower total number of wild food species. The disadvantage of the free listening method is that species less often used are underrepresented in the interview. Herbaceous species, for example, were rarely mentioned in our study. Since our surveys were conducted during the dry season, in which herbaceous species are not/rarely available, respondents might have forgotten species that are only available during the rainy season.

### 4.2 Species decline

Respondents described all wild food species as declining to a certain degree raising concern about the maintenance of these species in the future. This result is in accordance with Lykke et al. (1998, 2004), who studied species decline in western Senegal and northern Burkina Faso. This declining trend is caused by current land use intensifications (e.g. expansions of agricultural land, shortening of fallow periods), leading to a reduction of suitable habitats and an insufficient time for regeneration of native species during the fallow period (Nacoulma et al. 2011). The decline of these useful species might in addition be caused by a high exploitation rate (Wezel & Rath 2002) and unsustainable way of harvesting. *Parkia biglobosa*, for example, produces enough seedlings and saplings for reproduction but is sensitive to fire (Lykke 1998) and is therefore highly affected by field clearings trough fire and population pressure.

The observed very strong decline of the by far most economically important wild food species *Vitellaria paradoxa* and *P. biglobosa* (70% of wild food income) supposes serious impacts on rural household incomes in the future, which is in concordance with findings of Heubes et al. (2012). Both species are mainly preserved on cultivated lands. However, saplings are considerably cut back and reduced during field clearings, leading to an ageing of species' population (Djossa et al. 2008; Schreckenberg 1999).

### 4.3 Substitutes

The wide range of species mentioned as substitute for the wild food species showed that knowledge on alternative plant uses is high.

The list of substitute species contained almost exclusively native plant species and was very similar to the original cited wild food species list. Only three additional wild tree species were cited as substitutes (*Lannea acida*, *Lannea velutinum*, *Ziziphus abyssinica*). Interestingly, cultivated products, such as peanut oil as a substitute for shea butter (*Vitellaria paradoxa*) or other purchased products, such as Maggi as substitute for soumbala (*Parkia biglobosa*), were not cited. This suggests that these products are too costly for the interviewed households. In contrast, most valued wild food species were substituted with other highly valued wild food species. This indicates that many species were both, primary chosen wild food supplier as well as substitutes in case of shortfall of other primary wild food species. For example, the most cited substitute for the fruits of V. *paradoxa* were the fruits of *Lannea microcarpa* and the other way around. The same holds true for the fruits of *Ziziphus mauritiana* and *Balanites aegyptiaca* as well as for the leaves of *Adansonia digitata* and the calyxes of *Bombax costatum*. Therefore, the need to protect and sustainable manage native wild food species in woodland savanna and on fields/fallows becomes even more apparent. The loss of one species would additionally mean a loss of substitution alternatives of other wild food species.

*B. aegyptiaca* seems to be the most important substitute as it was by far the most frequently cited substitute and was mentioned as major surrogate for four of the ten wild food species. Its importance as substitute might be explained by the fact that *B. aegyptiaca*, known as the desert date, is a drought tolerant, typical Sahelian species, mostly fruiting during the dry season (Seghieri et al. 2009) and therefore a good supplement during the non-agricultural season. However, despite its drought tolerance, it was classified as strong-ly declining in our survey and might be not sufficiently available in the future. Likewise, Okia et al. (2011) found *B. aegyptiaca* to be declining in Uganda due to land clearings and increased grazing pressure.

Interestingly, the substitution pattern of *Tamarindus indica* differed to those of the other nine most cited wild food species as it was mainly substituted by an exotic tree (lemon) and by two native species (*Piliostigma* sp.) that were not mentioned as substitutes for the other important species. In terms of quantities, the two *Piliostigma* species seem to be "good" and available substitutes as they were not very important wild food species according to our interviews. However, in terms of qualities i.e. acidic flavour, lemons might be a better substitute for tamarind than the two *Piliostigma* species, but being on the same time more expensive.

The very low number of cited substitutes for *B. costatum* indicates that the impact on the traditional cuisine could

be high in case of species decrease or deficit. This is less the case for all other products since more substitutes were known.

#### 4.3.1 Relation of the choice in substitution to socio-economic-characteristics

For the majority of the most important wild food species, the substitution choice did not depend on socio-economic characteristics. This indicates that knowledge is more or less commonly shared among the informants, irrespective of age, ethnicity, education, village origin, income and farmland size. Accordingly, Sop et al. (2012) showed that the use of *Balanites aegyptiaca* did not differ between different ethnic groups in the sub-Sahel of Burkina Faso. Schumann et al. (2011) also found no distinct influence of household characteristics on knowledge distribution of the multipurpose tree species *Anogeissus leiocarpa*. However, for four species, substitution preferences depended on socio-economic characteristics.

Regardless of the similar characteristics of the villages, substitution preferences for three wild food species (*Lannea microcarpa*, *Tamarindus indica*, *Vitellaria paradoxa*) differed. One reason can be that more information was shared within villages than across villages. Another reason might be the access to different wild food species due to slight differences in precipitation between the villages. Even though both villages are situated in the North Sudanien vegetation zone, Kompienbiga is more humid, situated at the border to the South Sudanien zone. Similarly, Lykke et al. (2004) and Segnon & Achigan-Dako (2014) showed that food use preferences in the Sahel and Benin depend on village, in the same and in different phytogeographical regions, respectively.

Concerning differences between ethnicity, *Parkia biglobosa* was the only species whose substitution pattern differed. The autochthon Gourmantché knew twice as many substitution species compared to the migrated ethnic groups. A study in south-western Burkina Faso also found ethnicity to have an impact on choice of substitution for three high value NTFP species (Kaboré et al. 2015).

Regarding differences between income groups, substitution choice for *V. paradoxa* was more diverse for the poor and medium poor compared to the less poor ("richer") households. Owning less farmland, the access to the parkland tree *V. paradoxa* was usually lower for poorer households and therefore knowledge on substitutes was more diverse. The second most cited substitute for the poor and medium income groups was *Diospyros mespiliformis* and *P. biglobosa* for the less poor group. Since *P. biglobosa* is also a parkland tree, spared from field clearings, whereas *D. mespiliformis* is rather found in the savanna woodland, the same explanation pattern applies.

The investigated difference of substitution choice of *L. microcarpa* for households owning different farmland sizes can be explained in the same manner: Respondents holding more farmland cited *V. paradoxa* more often as substitute than households with less farmland available.

## 5 Conclusion

Knowledge on useful wild food species is profound and diverse in the study area. Concurrently, our results show that all species are declining in numbers, of which some contribute considerably to wild food income. In terms of biodiversity and nature protection in general, management recommendations should therefore focus on the whole ecosystem, rather than on only single species. However, to prevent negative economic impacts on livelihoods, management and protection strategies focusing especially on the economically most important species are additionally needed.

Generally, people in the study area are potentially able to counteract decline or absence of wild food by using a variety of substitutes. Substitutes are mainly native species, mostly belonging to the list of the ten most cited wild food species. Decline of one species might therefore increase the pressure on other native food species. Thus, the necessity to protect and sustainable manage native wild food species in woodland savanna and on fields/fallows is reinforced. Moreover, substitution choice is relatively conform between households of different characteristics. The combination of these results shows that maintaining the most important wild food species is crucial for all households irrespective of their characteristics.

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# Shared species of the spontaneous flora of a West African (Burkina Faso) and a Central European country (Germany)

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**Summary**: In spite of enormous climatic differences between Burkina Faso and Germany, 20 species belong to the spontaneous flora of both countries, i.e. 1 % of the flora of Burkina Faso and 0.5 % of the German flora. All of them are either ruderal and segetal species (16) or water and reed plants (4). All of the 16 ruderals/segetals are therophytes. From a recent point of view, most of the 20 species can be classified as cosmopolitan, because they cover three and more floristic zones, and/or at least three climatic zones, and/or are represented in at least three continents. Although Burkina Faso has a semi-arid climate, none of the species can be called a sclero- or xerophyte. Therefore, in Burkina Faso, all are more or less bound to habitats at least temporarily flooded or to humid soils. In Germany, however, the concerned ruderals, with one exception, are indicators of medium dry or dry habitats.

**Key words**: global change, cosmopolitan, hydrophytes, phytogeography, phytosociology, therophytes, ruderal species, segetal species, indicator values

### Espèces communes de la flore spontanée d'un pays Ouest-Africain (Burkina Faso) et d'un pays d'Europe centrale (Allemagne)

**Résumé:** En dépit des énormes différences climatiques entre le Burkina Faso et l'Allemagne, 20 espèces appartiennent à la flore spontanée des deux pays, ce qui représente 1 % de la flore du Burkina Faso et 0,5 % de la flore allemande. Toutes ces espèces sont soit rudérales et ségétales (16), soit des plantes aquatiques ou des marais (4). D'un point de vue récent, la plus part des espèces peuvent être classées en tant que cosmopolites. Bien que le Burkina Faso ait un climat semi-aride, aucune de ces espèces ne peut être appelée sclero- ou xérophyte. C'est pourquoi, au Burkina Faso, elles sont toutes plus ou moins liées à des habitats au moins temporairement inondés ou aux sols humides. En Allemagne cependant, en ce qui concerne les espèces rudérales, toutes sauf une sont des indicatrices de milieux semi-arides ou d'habitats secs.

**Mots clés**: cosmopolite, hydrophytes, valeurs indicatrices, phytogéographie, phytosociologie, espèces rudérales, espèces ségétales, thérophytes

### Gemeinsame Arten eines westafrikanischen (Burkina Faso) und eines mitteleuropäischen Landes (Deutschland)

**Zusammenfassung**: Trotz großer klimatischer Unterschiede zwischen Burkina Faso und Deutschland gibt es 20 Arten, die in beiden Ländern spontan vorkommen, das sind immerhin 1 % der Flora von Burkina Faso und 0,5 % der Flora Deutschlands. Mehrheitlich handelt es sich dabei um Arten der Ruderal- und/oder Segetalflora (16 Arten), die restlichen sind Wasser- bzw. Röhrichtpflanzen. Vom heutigen Standpunkt aus betrachtet, sind die meisten der 20 Arten Kosmopoliten. Obwohl das Klima von Burkina Faso semi-arid ist, gehört keine der Arten zur Gruppe der Sklero- oder Xerophyten. Dementsprechend sind in Burkina Faso alle mehr oder weniger an wenigstens temporär überflutete Standorte oder an feuchte Böden gebunden. 15 der 16 Ruderalen werden in Deutschland dagegen als Indikatoren intermediärer bis trockener Standorte bewertet.

**Schlagworte**: Hydrophyten, Kosmopoliten, Pflanzengeografie, Pflanzensoziologie, Ruderalarten, Segetalarten, Therophyten, Globaler Wandel, Zeigerwerte

## 1 Introduction

Regarding the great climatic differences between the Sudanian region of West Africa and Central Europe, it is not surprising that the spontaneous flora of the Sudanian country Burkina Faso and of the Central European Germany do not have many species in common. However, concerning ongoing acceleration of global change, it can be expected that the number of overlapping species will increase. Therefore, in the following, the recent situation is shown, i.e. species jointly present in the spontaneous flora of Burkina Faso and Germany are listed and some ecologic characteristics of these species are shown and discussed.

## 2 Methods

To identify species present in both countries, I compared the "*catalogue des plantes vasculaires du Burkina Faso*" (Thiombiano et al. 2012) with two common floras of Germany, the so-called "Rothmaler" (Jäger 2011) and the "Oberdorfer" (Oberdorfer 2001). For a summary of ecological characteristics, of phytogeography and of biology of the species, the ecological indicator values of the Central European flora (Ellenberg 1979), the atlas of the ferns and flowering plants of Germany (NetPhyD& BfN 2013) and the data collection BIOLFLOR (Klotz et al.2002) were used for the German point of view. The Burkinabé part was derived from Ataholo (2001), Wittig 2005 (a,b), Ouédraogo et al. (2005), Wittig et al. (2011) and Thiombiano et al. (2012).

## 3 Results

### 3.1. General overview

20 species that have been found occurring spontaneously in Germany are listed in the "*catalogue des plantes vasculaires du Burkina Faso*" as wild plants, too (Table 1). Two further species mentioned for the spontaneous flora of Germany are cultivated in Burkina Faso. These two species, i.e. *Ficus carica* and *Sorghum bicolor*, are not treated in the following.

The species shared between the two countries belong to 11 families, most of them represented by one species only. Amaranthaceae are represented by two, Asteraceae by three and Poaceae by five species (Table 1, column 1). Of the 20 species, 16 belong to the flora of anthropogenic and anthropisised habtitats, i.e. towns, villages, roadsides and other trodden areas, gardens, and arable land (Table 1, column 2). However, in the sense of Grime (1974), one of them (*Eleusine indica*) is not a ruderal, but a competitor (Table 1, column 3). The four remaining species are strongly bound to waters, because they live submerged (*Ceratophyllum demersum*), floating (*Trapa natans*) or in reeds (*Phragmites australis*, *Schoenoplectus litoralis*). While three of these four species are perennials, the ruderals are therophytes (Table 1, column 4). In Germany, four of these therophytes are facultative hemicryptophytes.

Regarding pollination vectors (Table 1, column 5) according to Durka (2002), most species concerned (65 %) need no vector but pollinate themselves or are apomictic. However, wind pollination also is important (40). With the exception of *Schoenoplectus litoralis*, all species are deciduous, showing their leaves during the vegetation period only (Ellenberg 1979). In Germany, the leaves of the two *Sonchus* species remain green during winter (Table 1, column 6). Fourteen of the ruderal species have (partly, or can develop) mesomorphic leaves; the leaves of *Oxalis corniculata* are hygromorphic (Table 1, column 7).

From a recent point of view, 90 % of the species can be classified as cosmopolitan, because they are represented in all continents except Antarctica (Table 1, column 8). But the term "cosmopolitan" does not mean that these species cover all climatic zones (Table 1, column 9). As far as their natural area is known, more species seem to originate from Eurasia (including the entire Mediterrane region) than from Africa South of the Sahara (Table 1, column 10), but only few are indigenous in Germany (Table 2).

Regarding ecological demands and phytosociologic affiliation of the species (Table 2), in Germany, except for *Sonchus oleraceus* (T = 5), the temperature indicator values assigned by Ellenberg (1979, 1991) are higher than 5 (Average 6.8, mean 7), i.e. these species prefer warm habitats. In Burkina Faso, many of the 16 ruderal species are indicators of humid or temporarily flooded soils. Contrarily, in Germany, their indicator value for soil humidity, which is known for ten species, ranges from 6 to 3 (average 4.3, mean 4). I.e., these species, in Germany, are mainly found on intermediate or (slightly) dry soils. The average and the mean indicator for soil reaction of the ruderal/segetal species is 7 (indicator of alkaline soils). This fits well with the fact that, in Burkina Faso, many of these species mainly grow on argillaceous or loamy soils (Thiombiano et al. 2012). According to their phytosociological affiliation in Burkina Faso and their indicator value for nitrogen supply in Germany (Table 2), all ruderal/segetal species can be regarded as indicating soils rich in nutrients.

### 3.2 Additional information

In the following, additional information is given on the 20 species listed in Table 1. All information shown in Table 1, i.e. life form, origin, indicator value in Central Europe, is not repeated.

*Amaranthus hybridus* L: In Germany, according to NetPhytD & BfN (2013), most information on this species is doubtful, because it is often not clear, whether its mentioning in literature refers to *A. hybridus* L. s. str. or to *A. hybridus* agg. However, it is clear, that *A. h.* s. str. has been found occasionally in Germany – its first finding could be dated to 1950 (Jäger 2011) – but that it is not established Germany up to now. In Burkina Faso, it is used as ingredient of sauces (Wittig & Martin 1995) and has numerous applications in traditional medicine (Nacoulma-Ouédraogo 1996). Therefore, it is tolerated in the vicinity of villages. However, considering the releves of ruderal and segetal communities available up to now (Böhm 2001, Kéré 1998, and Wittig et al. 2011), compared to some other *Amaranthus* species, it seems to be rare. The African Plant Database (CJB 2012), in the following abbreviated as APD does not even indicate it for Burkina Faso.

*Bidens pilosa* L. too, is not indicated for Burkina Faso by APD. Also its phytosociological documentation is very sparce. In the region of Tenkodogo, Kéré (1998) found it in three of fife releves of a comparatively undisturbed savanna type. Hoff & Brisse (1983) estimate that it is characteristic of a pantropical class of young postcultural vegetation, the class Soncho-Bidentetea pilosae Hoff et al. 1983. In Germany, it is very rare and not established.

*Celosia argentea* L.: In both countries, this species, originating from Asia, is sometimes cultivated as ornamental plant. While it is naturalized in Burkina, the rare findings in Germany probably are garden escapees, i.e this species is not established.

*Ceratophyllum demersum* L. is a submerged water plant, but is not strictly bound to permanent waters, because its turions can survive in muddy soil. APD does not indicate it for Burkina Faso. In Germany, it belongs to the most frequent water plants.

*Chamaesyce prostrata* (Aiton) Small, conservatively named *Euphorbia prostrata* Aiton by Thiombiano et al. (2012), is the only chamaephyte among the 16 ruderals under concern. It is neither indicated by APD for Burkina Faso nor by the Atlas for Germany.

*Echinochloa crus-galli* (F.) P.Beauv. is only very briefly described by Thiombiano et al. (2012) and not indicated by APD. We can therefore conclude that this species in Burkina Faso is very rare. In Germany, it is a frequent, well-established archaeophyte.

**Table 1: general information on the species / Tableau 1: Informations générales sur les espèces**

| Column No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Family** | **Habitat** | **Strategy** | **Life Form** | **Pollination (main type)** | **Leaf Persistence** | **Leaf Anatomy** | **Recent Area** | **Climate** | **Natural Area** |
| *Amaranthus hybridus* | Amaranthaceae | a | CR | T | wi, se | v | m | all | m, t | |
| *Bidens pilosa* | Asteraceae | a | *CR* | *T* | *se* | *v* | *m* | all | | *SAm* |
| *Celosia argentea* | Amaranthaceae | a | R | T | wi, se | v | m | all | | *SAm* |
| *Ceratophyllum demersum* | Ceratophyllaceae | w | | Hy | wa | v | hd | all | st, t | *ww* |
| *Chamaesyce prostrata* | Euphorbiaceae | a | R | T | in | v | sc, m | all | | |
| *Echinochloa crus-galli* | Poaceae | a | CR | T | wi, se | v | m | all | te,m,st,t | Af, As |
| *Eleusine indica* | Poaceae | a | C | T | wi | v | sc, m | all | st, t | Af, As, E |
| *Eragrostis cilianensis* | Poaceae | a | R | T | wi | v | sc, m | all | te,m,st,t | As, E |
| *Eragrostis pilosa* | Poaceae | a | R | T | wi, ap | v | sc, m | all | te,m,st,t | As, E |
| *Oxalis corniculata* | Oxalidaceae | a | R | T, He | se | *v* | hg | all | te,m,st,t | ww |
| *Phragmites australis* | Poaceae | w | CS | Hg, G | wi | v | he | Af, Am, As, E | all | ww |
| *Portulaca oleracea* | Portulacaceae | a | R | T | se | v | su | all | te,m,st,t | Af, As, E |
| *Schoenoplectus litoralis* | Cyperaceae | w | CS | G | wi | i | he, hg | all | | |
| *Setaria pumila* | Poaceae | a | R | T | se | v | sc, m | all | t, m, st | As, E |
| *Setaria verticillata* | Poaceae | a | CR | T | se | v | sc, m | all | t, m, st | Af, As, E |
| *Solanum nigrum* | Solanaceae | a | R | T | se | v | m | all | all | ww |
| *Sonchus asper* | Asteraceae | a | CR | T, He | in, se | v+ | m | all | b ,te, m | As, E |
| *Sonchus oleraceus* | Asteraceae | a | CR | T, He | se | v+ | m, hg | all | b, te | As, E |
| *Trapa natans* | Trapaceae | w | | Hg, T | se | v | hd | Af, Am*, As, E | te ,m, st | Af, As, E |
| *Tribulus terrestris* | Zygophyllaceae | a | | *T, He* | | *v* | *m* | all | | *Af, As, Au, E |

**Abbreviations**

**Habitat**: a anthropogenic or highly influenced by human activities (= ruderal or segetal), w waters

**Strategy** (Grime 1974): C competitive, CR between C and R, CS between C and S, R ruderal, S stress tolerant

**Life form** (Raunkiaer 1934): G geophyte, He hemicryptophyte, Hg hygrophyte, T therophyte; some species can realize zwo life forms

**Pollination**: ap apomictic (no pollination needed), in insects, se self, wa water, wi wind, some species show two pollination mechanisms

**Leaf persistence**: i indeciduous, *v* vegetation period, v+ in Europe vegetation period + winter

**Leaf anatomy**: he helomorphic, hd hydromorphic, hg hygromorphic, m mesomorphic, sc scleromorphic, su succulent; some species have (or can develop) two types of leaves

**Recent area**: all all continents, Af Africa, Am America, Am* North America, As Asia, E Europe

**Climate**: b boreal, m meridional (in all cases including submeridional), st subtropical, te temperate, t tropical

**Natural area**: Af Africa, Am America, As Asia, Au Australia, E Europe and the mediterranean area, SAm South America, ww world-wide; *information for Tribulus: from EOL

**Sources**: if information is not written in italicis / si les informations ne sont pas écrites dans italicis: Column 1-7, 9, 10: Klotz et al. (2002), col. 8: GBIF (2015); for information in italicis: classification due to own experience or knowledge / pour des informations en italique: classement en raison de propre expérience ou connaissance

**Table 2: Habitats and phytosociology in Burkina Faso, selected indicator values and floristic status in Germany**
**Tableau 2:Habitats et phytosociologie au Burkina Faso, valeurs indicatrices et status floristique pour l'Allemagne**

| Species | Burkina Faso | | Germany | |
|---|---|---|---|---|
| | **Habitats** (Thiombiano et al. 2012) | **Phytosociologic affiliation** | **Indicator values** T F R N | **Floristic** status |
| *Amaranthus hybridus* | ruderal area | *Commelinetalia benghalensis* | 8 4 7 7 | u |
| *Bidens pilosa* | humid soils | weed in rice fields (1) | | u |
| *Celosia argentea* | humid soils | Aeollanthetum pubescentis (2) | | u |
| *Ceratophyllum demersum* | permanent waters | Nymphaeetea loti (3) | 7 s 8 8 | i |
| *Chamaesyce prostrata* | trodden areas | | | u |
| *Echinochloa crus-galli* | (no information) | | 7 5 x 8 | a |
| *Eleusine indica* | ruderal, trodden areas | Eleusine indica-communities (4)<br>Commelinetalia benhgalensis (2) | | u |
| *Eragrostis cilianensis* | ruderal areas | | | u |
| *Eragrostis pilosa* | flooded depressions | Eragrostio pilosae-Echinochloetum col. (5) | 7 3 x ? | e |
| *Oxalis corniculata* | fallows, gardens | *Commelinetalia benghalensis* | 7 4 x 6 | e |
| *Phragmites australis* | reeds | *Cyperetea papyri (=Phragmitetea p.p.)* | 5 e 7 7 | i |
| *Portulaca oleracea* | open humid soils rich in nutrients; often degraded by trampling | Eleusine indica-communities (4;)<br>*also Soncho-Bidentetea pilosae* | 8 4 7 7 | a |
| *Schoenoplectus litoralis* | brackish waters | *Cyperetea papyri (=Phragmitetea p.p.)* | | u |
| *Setaria pumila* | open periodically flooded soils; arable land, fallows | Echinochloetea colonae (5)<br>Alysicarpetalia ovalifolii (2) | 7 4 5 6 | a |
| *Setaria verticillata* | open periodically flooded soils; also shrubbery and segetal | *Echinochloetea colonae* | 7 4 x 7 | a |
| *Solanum nigrum* | arable land, gardens | *Soncho-Bidentetea pilosae* | 6 5 7 8 | a |
| *Sonchus asper* | gardens, very humid soils | *Commelinetalia benghalensis* | 5 6 7 7 | i |
| *Sonchus oleraceus* | gardens, humid soils | *Commelinetalia benghalensis* | 6 4 8 8 | i |
| *Trapa natans* | permanent waters | Neptunio-Trapetum natantis (6) | 7 n 6 8 | i |
| *Tribulus terrestris* | ruderal area, fallows | Eleusine indica-communities (4) | | u |

**Abbreviations**

**Phytosociology:** C: 1 Ataholo (2001); 2 Wittig et al. (2011); 3 Wittig (2005a): 4 Böhm (2001); 5 Wittig (2005b); 6 Ouédraogo et al. (2005)

if no source is mentioned, the phytosociology of the species is not (or not sufficiently) documented; in some cases (italic letters) it is the result of a synthesis of literature research and the own experience of the author

**Indicator values** (Ellenberg 1979)**:** 1 lowest value, i.e. indicator of coolest habitats existing in Germany, of very dry soils, of very low soil reaction, of very low nitrogen supply 9 highest value, i.e. indicator of warm habitats existing in Germany etc

f floating, s submerged, r reed plants; x no indicator value

**Floristic status** (Kühn & Klotz 2002)**:** a established archaeophyte, i indigenous, n established neophyte, u not established

*Eleusine indica* (L.) Gaertn. has been ranked as character species of the alliance Eleusinion indicae Schmitz 1971 which was described for paleotropical communities of trodden areas (Schmitz 1971). In Burkina Faso, *E.i.* is very frequent, in Germany very rare and not established.

*Eragrostis cilianensis* (All.) Vignolo ex Janch is scarcely represented in Bukina Faso`s phytosociologic literature, however very well by herbarium specimen in Ouagadougou and Frankfurt. In Germany it is very rare, but a comparison of older with more recent editions of the most common Floras of Germany reveals that it is recently expanding on trodden areas.

*Eragrostis pilosa* (L.) P.Beauv. was identified by Wittig (2005) as diagnostic species of the Eragrostio pilosae-Echinochloetum colonae, one of the typical plant communities of temporarily flooded depressions (*bas fonds*) in the Sahelian zone of Burkina Faso. In Germany, it is obviously expanding and much more frequent than *E. cilianensis*.

*Oxalis corniculata* L.: For this species, Thiombiano et al. (2012) give only one reference and mention no herbarium specimen. Obviously this species, which becomes more and more common in Germany, is rare in Burkina Faso. Because no natural habitat is known for *O.c*., we can assume that it has developed on anthropogenic or anthropisised sites, i.e. it is an anecophyte (Scholz 1995)

*Phragmites australis* (Cav.) Steud. is very common in Germany. APD does not indicate it for Burkina Faso.

*Portulaca oleracea* L.: In both countries, *P. o.* is occasionally cultivated, because some people eat it as salad. Therefore, we cannot exclude, that some plants found growing spontaneously might be garden escapees. Nevertheless it can be regarded as established in Burkina Faso and Germany. Like *Oxalis corniculata*, it is an anecophyte.

*Schoenoplectus litoralis* (Schrad.) Palla is very rare in both countries. In Burkina Faso it might be indigenous, in Germany it is not established.

*Setaria pumila* (Poir.) Roem. et Schult., in the phytosociological literature of Burkina Faso documented by numerous releves (mostly named *Setaria pallide-fusca*), is a diagnostic species of the Setario pallidae-fuscae Echinochloetum colonae Wittig 2005, one of the typical plant communities of temporarily flooded depressions (*bas fonds*) in the Sahelian zone of Burkina Faso. It is the only plant of the 20 species concerned, which is more or less common in both countries.

*Setaria verticillata* (L.) P.Beauv. is only scarcely represented in the phytosociological literature of Burkina Faso. In Niger, it is often associated to *Echinochloa colona* (Poilecot 1999), i.e. it might be characteristic of the alliance *Echinochloion colonae* Wittig 2005.

*Solanum nigrum* L., *Sonchus asper* (L.) Hill and *Sonchus oleraceus* L. are frequent in Germany, but not mentioned for Burkina Faso by APD. In the rich phytosociologic literature existing for Burkina Faso, they are only scarcely mentioned. Therefore we can estimate that they are rare in Burkina Faso. Perhaps they are affiliated to the class Sancho-Bidentetea pilosae Hoff et al. 1983. *Solanum nigrum* is an anecophyte.

*Trapa natans* L.: Like the three water and reed species mentiond above, *T. n.* is not indicated for Burkina Faso by APD, but herbarium specimen exist from different lakes and mares (see Thiombiano et al. 2012) and its phytosociology was documented by Ouédraogo et al. (2005). In Germany, it is very rare.

*Tribulus terrestris* L. is common in Burkina Faso, from where it is particularly documented for (mainly Sahelian and North-Sudanian) ruderal communities degraded by trampling (Böhm 2001). For Germany, it is the rarest one of the 20 species treated in this publication (mentioned by Jaeger 2011, but neither by Oberdorfer 2001 nor by the Atlas).

## 4 Discussion

With regard to the climatic differences – Germany has a temperate climate with rain comparatively equally distributed all over the year, while Burkina Fasos climate is semi-arid – it could not be expected that the spontaneous flora of these countries contains 20 shared species. Not surprisingly, most of the species are therophytes occurring only on anthropogenic or disturbed habitats. In Germany, seven of them are classified as (strongly) urbanophilic (*Amaranthus hybridus, Celosia argentea, Chamaesyce prostrata, Eleusine indica*, *Eragrostis cilianensis*, *Eragrostis pilosa*, *Portulaca oleracea*) meaning that they occur mainly or only in urban areas (Wittig et al. 1985, Klotz & Kühn 2002).Obviously they are not able to compete with indigenous species (nor in Germany, nor in Burkina) so that they can only survive on places where competition is reduced notably. And of the aquatic and semi-aquatic plants, which represent the rest of the species treated, it is well known that they less depend on climate than terrestrial plants, because regional climatic differences are locally mitigated by large waters. In Burkina Faso, interestingly even the 16 ruderals are more or less bound to humid or temporarily flooded soils. That these species in Germany are regarded as indicators of only intermediately humid or even dry soils, is a confirmation of the rule of habitat constancy established by Walter & Walter (1953).

Although all species treated here are cosmopolitan, most of the 16 ruderals are not very frequent, neither in Germany nor in Burkina Faso. Exceptions are *Echinochloa crus-galli*, *Oxalis corniculata*, *Solanum nigrum* and the two *Sonchus* species for Germany, as well as *Eleusine indica*, *Setaria pumila* and *Tribulus terrestris* for Burkina Faso. In the maps shown by The African Pant Database (CJB 2012), only eight of these 16 species are indicated for Burkina Faso. In Germany, *Echinochloa crus-galli*, *Oxalis corniculata*, *Setaria pumila*, *S. verticillata* and *Solanum nigrum* have shown increasing frequency and expanded their area during the past three or four decades; the two *Eragrostis* species are expanding recently. Therefore, it can be expected that some of those species of Table 1 that are presently rare in Germany, will expand in the future, due to increasing temperatures and traffic. For Burkina Faso, the direction of climate change and its interaction with the rapid population increase is discussed contrarily (e.g. Scheiter & Higgins 2008, Heubes et al. 2011). Therefore, it is not possible to predict, whether

more species that up to now only occur in temperate regions of the world, will immigrate to Burkina Faso or escape from ornamental gardens, where some of them are cultivated.

Regarding the four water and reed species, *Ceratophyllum demersum* and *Phragmites australis* are very common in Germany, while *Schoenoplectus litoralis* and *Trapa natans* are extremely rare. Surprisingly, none of them is shown for Burkina Faso in the maps of the African Plant Database (CJB 2012). Therefore, we can conclude that they are generally rare. However, for *Ceratophyllum demersum* and *Trapa natans*, it is confirmed that they are locally frequent (Ouedraogo et al. 2005). Obviously, floristic research in Burkina Faso is still worthwhile.

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