

Flora_{et} Vegetatio Sudano-Sambesica



edited by
éditées par
herausgegeben von

Rüdiger Wittig¹
Sita Guinko²
Brice Sinsin³
Adjima Thiombiano²

¹Frankfurt

²Ouagadougou

³Cotonou

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Editor-in-Chief:

Prof. Dr. Rüdiger Wittig
Institute of Ecology, Evolution & Diversity
Department of Ecology and Geobotany
Siesmayerstraße 70, Haus B
60323 Frankfurt am Main

eMail:
r.wittig@bio.uni-frankfurt.de

Co-Editors:

Prof. Dr. Sita Guinko
Prof. Dr. Adjima Thiombiano

Sciences de la Vie et de la Terre
Laboratoire de Biologie et Ecologie Végétales
Université de Ouagadougou
03 BP 7021 Ouagadougou
Burkina Faso

eMail:
sguinko@univ-ouaga.bf
adjima_thiombiano@univ-ouaga.bf

Prof. Dr. Brice Sinsin
Faculté des sciences Agronomiques
Laboratoire d'Ecologie Appliquée
Université Nationale du Benin
B.P. 526 Cotonou
Benin

eMail:
bsinsin@gmail.com

Editorial-Board

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Department of Ecology and Geobotany
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Universität Rostock
18057 Rostock / Germany

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World-wide every fifth vascular plant species is or was used as medicinal or aromatic plant¹

Rüdiger Wittig, Theo Dingermaier, Robert Sieglstetter, Yingzhong Xie, Adjima Thiombiano and Karen Hahn

Summary: It is common knowledge that plants have been the world-wide most important source of medicines and that they still play this role in developing countries. However, up to now, complete lists of medicinal and aromatic plants (MAP) exist for comparatively few countries. A review of all lists known to the authors reveals the following results:

A total of 20.7 % of the plant species analyzed by either publications or own research are or were used as MAP. However, regarding single countries, the differences are considerably high. Absolutely leading the list are China (36.2 %), Burkina Faso (35.2 %) and the Korean Republic (34.5 %). Also ahead of other countries or regions are the North of Benin (32.8 %) and the entire Pakistan (30.3 %). Still above average rank Great Britain (26.7 %) and Nepal (23.3 %), while the figures for Bulgaria (21.0 %), Germany (20.2 %) and France (19.4 %) almost represent the average. Jordan (17.3 %), Vietnam (17.1 %), Sri Lanka (16.6 %), India (16.1 %) and Thailand (15.5 %) rank slightly beneath. Clearly below the average are the percentages of MAP for Hungary (12.2 %) and the USA (11.8 %). The average numbers of MAP in the Philippines (9.5 %) and Malaysia (7.7 %) fall far behind.

Calculated on a worldwide scale, every fifth plant can be regarded as MAP. This number matches that from Bulgaria, France and Germany. In northern Benin, Burkina Faso, Korea, China and Pakistan, however, every third plant is or was used as MAP, whereas in Hungary and the USA only every eighth plant can be regarded as MAP. This number drops even further for the Philippines or Malaysia where only every tenth or thirteenth plant can be attributed to medicinal or aromatic use. These differences might be due to various factors.

A geographical component of the results is obvious: in most cases geographically close countries show similar percentages. A correlation between the total number of species and the fraction of those used as MAP cannot be confirmed. The countries with percentage of MAP > 30 % in common show that they belong either entirely (Burkina Faso, Benin) or at least in their rural areas to the poorest countries of the world so that it is (was) impossible for the majority of the people to buy "modern" MAP. In those countries the number of traditional healers outnumbers largely the number of modern doctors. Therefore, the tradition of folk medicine was maintained until today. Additionally, China, Korea and partially Pakistan have a very old and well documented tradition of folk medicine. Due to this documentation even in areas where today "modern MAP" are used, the knowledge was not lost.

In neighboring countries or regions, which differ with respect to a more arid or a more humid climate, for the arid country (region) more MAPs are reported than for the humid one. The potential reasons for this phenomenon are discussed in the paper.

For many countries the percentage given for MAP in literature is too low. But even these low values represent a striking argument for the importance of a world-wide conservation of biodiversity.

Key words: biodiversity, ethnobotany, MAP, traditional medicine.

A L'ÉCHELLE MONDIALE LE 5ÈME DES ESPÈCES DE PLANTES VASCULAIRES EST OU A ÉTÉ UTILISÉ COMME PLANTE MÉDICINALE OU AROMATIQUE

Résumé: Il est bien connu que des plantes ont été la source la plus importante des médicaments dans le monde entier et qu'elles jouent encore ce rôle dans les pays en voie de développement. Cependant, jusqu'à présent, les listes complètes des plantes médicinales et aromatiques (PAM) n'existent relativement que pour peu de pays. Un examen de toutes les listes connues des auteurs révèle les résultats suivants:

Un total de 20,7% des espèces de plantes examinées soit à travers des publications ou de nos propres recherches sont ou ont été utilisées comme MAP. Toutefois, en considérant les pays individuellement, les différences sont considérablement importantes. En tête de liste se trouvent incontestablement la Chine (36,2%), le Burkina Faso (35,2%) et la République de Corée (34,5%). Les autres pays ou régions qui se classent en tête sont le Nord-Bénin (32,8%) et le Pakistan (30,3%). Toujours au dessus du classement moyen se trouvent la Grande-Bretagne (26,7%) et le Népal (23,3%), alors que la Bulgarie (21,0%), l'Allemagne (20,2%) et la France (19,4%) se retrouvent dans la catégorie moyenne. La Jordanie (17,3%), le Vietnam (17,1%), le Sri Lanka (16,6%), l'Inde (16,1%) et la Thaïlande (15,5%) se classent légèrement en dessous. La Hongrie (12,2%) et les États-Unis (11,8%) présentent des pourcentages moyens en PAM nettement en dessous de la moyenne. Les nombres moyens de MAP en Philippines (9,5%) et en Malaisie (7,7%) sont loin derrière.

Les différences entre certains pays sont frappantes: calculé à l'échelle mondiale, chaque cinquième de plantes peut être considéré comme MAP. Ce nombre correspond à celui de la Bulgarie, de la France et de l'Allemagne. Cependant, dans le Bénin, le Burkina Faso, la Corée, la Chine et le Pakistan, chaque tiers (1/3) de plantes est ou a été utilisée comme PAM, alors dans la Hongrie et les États-Unis seulement chaque huitième (1/8) de plantes peut être considéré comme MAP. Ce nombre baisse davantage pour les Philippines ou la Malaisie, où seulement chaque dixième (1/10) ou treizième (1/13) de plantes peut être attribué à un usage médicinal ou aromatique. Ces différences pourraient être dues à divers facteurs comme:

Le caractère géographique des résultats est évident: dans la plupart des cas, les pays géographiquement proches affichent des pourcentages similaires. Une corrélation entre le nombre total d'espèces et la fraction de celles utilisées comme MAP ne peut être confirmée. Les pays ayant en commun le pourcentage de MAP > 30% appartiennent soit entièrement (Burkina Faso, Bénin) ou au moins leurs zones rurales aux pays les plus pauvres du monde de sorte qu'il est (était) impossible pour la

majorité de la population d'acheter les médicaments "modernes". Dans ces pays, le nombre de tradipraticiens dépasse largement le nombre de médecins. Par conséquent, la tradition de la médecine folklorique a été maintenue jusqu'à nos jours. En outre, la Chine, la Corée et partiellement le Pakistan ont une tradition très ancienne et bien documentée de la médecine folklorique. Grâce à cette documentation, même dans les zones où aujourd'hui «les MAP modernes» sont utilisées, la connaissance n'est pas perdue.

Dans les pays ou régions voisines, différant par rapport à l'aridité ou à l'humidité du climat, plus de MAPs sont signalées dans les pays arides (régions) contrairement à ceux humides. Les raisons possibles de ce phénomène sont discutées dans l'article.

Pour de nombreux pays, le pourcentage donné des PAM dans la littérature est trop faible. Malgré tout, ces faibles valeurs indiquent clairement l'importance d'une conservation de la biodiversité à l'échelle mondiale.

Mots clés: biodiversité, ethnobotanique, médecine traditionnelle, PAM

WELTWEIT WIRD ODER WURDE JEDE FÜNFTE GEFÄßPFLANZENART ALS MEDIZINAL- ODER AROMA-PFLANZE GENUTZT

Zusammenfassung: Es ist allgemein bekannt, dass Pflanzen früher weltweit die wichtigste Heilmittel-Quelle waren und es in Entwicklungsländern heute noch sind. Jedoch gibt es bisher nur für relativ wenige Länder eine komplette Liste der Medizin- und Aroma-Pflanzen (MAP). Eine Auswertung aller den Autoren bekannten Listen erbrachte folgende Resultate:

Insgesamt werden oder wurden 20,7 % der in den ausgewerteten Arbeiten enthaltenen Arten als MAP genutzt. Bezüglich der einzelnen Länder bestehen jedoch große Unterschiede: Führend hinsichtlich des Anteils genutzter Arten sind China (36,2 %), Burkina Faso (35,2 %) und die Republik Korea (34,5 %). Weit vorne liegen auch der Norden Benins (32,8 %) sowie Pakistan (30,3 %), noch über dem Durchschnitt rangieren Großbritannien (26,7 %) und Nepal (23,3 %), während die Prozentzahlen von Bulgarien (21,0 %), Deutschland (20,2 %) und Frankreich (19,4 %) ungefähr der Durchschnitt repräsentieren; Jordanien (17,3 %), Vietnam (17,1 %), Sri Lanka (16,6 %), Indien (16,1 %) und Thailand (15,5 %) liegen knapp darunter. Klar unterdurchschnittlich sind die Zahlen für Ungarn (12,2 %) und die USA (11,8 %); die Philippinen (9,5 %) und Malaysia (7,7 %) liegen weit hinten.

Im weltweiten Durchschnitt hat also jede fünfte Gefäßpflanzenart MAP-Eigenschaften. In Benin, Burkina Faso, Korea, China und Pakistan trifft dies sogar für jede dritte Art zu, in Ungarn und USA dagegen nur für jede achte, auf den Philippinen und in Malaysia lediglich für jede zehnte bzw. dreizehnte. Diese auffälligen Unterschiede können verschiedene Ursachen haben.

Sofort sichtbar ist eine geografische Komponente: dicht benachbarte Länder zeigen in der Mehrzahl der Fälle ähnliche Werte. Dagegen kann keine Beziehung zwischen der Gesamtzahl der Arten und dem Anteil der MAP konstatiert werden. Allen Ländern mit hohem MAP-Prozent ist gemeinsam, dass sie entweder vollständig oder wenigstens in ihren ländlichen Bereichen zu den ärmsten Regionen der Welt gehören (Burkina Faso, Benin) oder bis vor wenigen Jahrzehnten gehörten (China), so dass es der Mehrzahl der Bevölkerung unmöglich war, „moderne“ Arzneien zu kaufen. In diesen Ländern übertrifft oder übertraf bis vor kurzem die Zahl der traditionellen Heiler die der studierten Mediziner. Aus diesem Grunde hat die Volksmedizin bis heute überlebt. Zusätzlich existiert in China, Korea und teilweise auch in Pakistan eine gute Dokumentation der Volksmedizin, weshalb auch in Gebieten, in denen heute die „moderne“ Medizin Einzug gehalten hat, das Wissen um die traditionellen MAP nicht verloren gegangen ist.

In benachbarten Ländern oder Regionen, die sich bezüglich der Aridität bzw. Humidität des Klimas unterscheiden, ist der Anteil der MAP in den ariden Gebieten höher. Die vielfältigen potentiellen Erklärungen für dieses Phänomen werden im vorliegenden Aufsatz diskutiert.

Für mehrere Länder ist der in der Literatur zu findende Anteil an MAP zu niedrig. Aber selbst diese Werte bilden einen überzeugenden Beweis für die Wichtigkeit einer weltweiten Bewahrung der Biodiversität.

Schlagworte: Biodiversität, Ethnobotanik, MAP, traditionelle Medizin

1 INTRODUCTION

It is common knowledge that plants have been the worldwide most important source of medicines and that they still play this role in developing countries (SOFOWARA 1996; The delegates of the Conference on Traditional Medicine in ASEAM Countries 2010), particular in remote areas (e.g. CANIAGO & SIEBERT 1998, WECKERLE et al. 2005). But even in highly developed Western countries they have maintained a leading position as source of medicines as shown for the period of 1981-2002 by NEWMAN et al. (2003). In Germany for example, 75% of the population regularly use some form of traditional complementary and alternative medicine (MARSTEDT & MOEBUS 2002), in Canada 70% (Health Canada 2001) and in England 47% (THOMAS et al. 2001). Many reviews and comprehensive books documenting and explaining this importance exist (e.g. PRAJAPATI et al. 2005; RAO et al. 2005; BOGERS et al. 2006; KAYNE 2010). As there is

no doubt that medicinal plants will be also very important for tomorrow's pharmacy (Lewis 2003; Craker & Gardner 2006), it is of great interest, how many plants have already been used as pharmaceutical (medicinal and aromatic) plants up to now. In the following, we answer this question by a literature search combined with data from own investigations in West Africa (e.g. WITTIG et al. 2000, 2002, 2009). The results will be an important contribution to the discussion on the importance of ecosystem services (see e.g. COSTANZA et al. 1997; MILLENIUM ECOSYSTEM ASSESSMENT 2005) and the value of biodiversity (e.g. BALMFORD et al. 2002; EUROPEAN COMMUNITIES 2008). As collecting wild plants for pharmaceutical purposes is still very common in most regions of the Sudano-Sambesian zone, we consider our paper suitable for Flora et Vegetatio Sudano-Sambesica.

2 SOURCES AND METHODS

Up to now, complete lists of medicinal and aromatic plants (MAP) exist only for comparatively few countries. Luckily these lists comprise some of the largest countries so that our question can be answered on a sufficiently broad basis. Nevertheless, we completed the available lists by own investigations.

The following sources and methods were used:

- Benin: results of an own intensive ethnobotanical research in the North of Benin were assumed to be valid for the whole country;
- Bulgaria: HARDALOVA et al. (1998);
- Burkina Faso: we conducted a detailed countrywide ethnobotanical research; in all parts of the country, healers and old women (the knowledge on MAP is particular passed on by women) were interviewed by using a standardised questionnaire; additionally we used the results of NACOULMA OUEDRAOGO (1996);
- China: YANG (2006);
- Germany: all species named as MAP in the Flora of Germany (OBERDORFER 2001) and all species listed in particular books on Germany's medicinal plants (WICHTL 2002, SCHÖNFELDER & SCHÖNFELDER 2004, VAN WYK et al. 2004) in relation to the total species number in OBERDORFER (2001; aggregates were rated as one species);
- Great Britain and Ireland: all species listed by ALLEN & HATFIELD (2004) in relation to the total number of native and naturalised species (based on CLAPHAM et al. 1993);
- India: JAIN & DEFILLIPPS (1991);
- Jordania: ORAN & ALI-EISAWI (1998);
- Nepal: HAMILTON & RADFORD (2007);
- Pakistan: ZAHOR (1997);
- USA: MOERMAN (1996);
- All other countries mentioned in Table 1: SCHIPMANN et al. (2006).

The series *médecine traditionnelle et pharmacopée*, edited in Paris by the Agence de Cooperation Culturelle et Technique (ACCT) which covers most francophone African countries (see LEJOLY 1993) was not considered in the results, because we realized by the example of Benin (ADJANOHOON et al. 1989) that only well-known and often used species are represented.

3 RESULTS

A total of 20.7 % of the plant species analyzed by either publications or own research are or were used as MAP. However, regarding single countries, the differences are considerably high. Absolutely leading the list are China (36.2 %), Burkina Faso (35.2 %) and the Korean Republic (34.5 %). Also ahead of other countries are Benin (32.8 %) and Pakistan (30.3 %). Still above average rank Great Britain (26.7 %) and Nepal (23.3 %), while the figures for Bulgaria (21.0 %), Germany (20.2 %) and France (19.4 %) almost represent the average. Jordan (17.3 %), Vietnam (17.1 %), Sri Lanka (16.6 %), India (16.1 %) and Thailand (15.5 %) rank

slightly beneath. Clearly below the average are the percentages of MAP for Hungary (12.2 %) and the USA (11.8 %). The average numbers of MAP in the Philippines (9.5 %) and Malaysia (7.7 %) fall far behind.

Table 1: Number of PAM in relation to the total number of plant species / Nombre de PAM par rapport au nombre total d'espèces de plantes / Anzahl der PAM im Verhältnis zur Gesamtzahl der Arten

Country	total number of vascular plants	number of MAP	
		absolute	relative
Benin, Atakora region	2807	921	32.8%
Bulgaria	3567	750	21.0%
Burkina Faso	1696	597	35.2%
China, total	35364	12807	36.2%
China, NW	ca. 3900	ca. 2300	58.9%
Germany	2475	501	20.2%
France	4630	ca. 900	29.4%
Great Britain*	1503	402	26.7%
Hungary	2214	270	12.2%
India	18664	ca. 3000	16.1%
Jordan	ca. 2100	363	17.3%
Korea (Rep. of)	2898	ca. 1000	34.5%
Malaysia	ca. 15500	ca. 1200	7.7%
Nepal	6973	1625	23.3%
Pakistan	4950	ca. 1500	30.3%
Philippines	8931	ca. 850	9.5%
Sri Lanka	3314	ca. 550	16.6%
Thailand	11625	ca. 1800	15.5%
USA	21641	2564	11.8%
Vietnam	ca. 10500	ca. 1800	17.1%
total	133252	20800	20.2%

*and Ireland

Sources: Benin: SIEGLSTETTER (2002); Bulgaria: HARDALOVA et al. (1998); Burkina Faso: results of our own detailed countrywide ethnobotanical research were combined with that of NACOULMA OUEDRAOGO (1996); China: YANG (2006); Germany: all species named as MAP in the Flora of Germany (OBERDORFER 2001) and all species listed in particular books on Germany's medicinal plants (WICHTL 2002, SCHÖNFELDER & SCHÖNFELDER 2004, VAN WYK et al. 2004) in relation to the total number of native and naturalised species (OBERDORFER 2001; apomictic aggregates were rated as one species); Great Britain and Ireland: all species listed by ALLEN & HATFIELD (2004) in relation to the total number of native and naturalised species (based on CLAPHAM et al. 1993); India: JAIN & DEFILLIPPS (1991); Jordan: ORAN & ALI-EISAWI (1998); Nepal: HAMILTON & RADFORD (2007); mean of several estimations; Pakistan: ZAHOR (1997); USA: MOERMAN (1996); All other countries: SCHIPMANN et al. (2006).

Sources: Bénin: SIEGLSTETTER (2002); Bulgarie: HARDALOVA et al. (1998); Burkina Faso: les résultats de nos propres recherches ethnobotaniques à l'échelle nationale ont été combinés à ceux de NACOULMA OUEDRAOGO (1996); Chine: YANG (2006); Allemagne: toutes les espèces désignées comme MAP dans la Flore de l'Allemagne (OBERDORFER 2001) et toutes les espèces énumérées dans les livres particuliers sur les plantes médicinales de l'Allemagne (WICHTL 2002, SCHÖNFELDER ET SCHÖNFELDER 2004, VAN WYK et al. 2004.) par rapport au nombre total d'espèces locales et exotiques (OBERDORFER 2001; les agrégats apomictiques ont été considérés comme une espèce); grande-Bretagne et l'Irlande: toutes les espèces énumérées par ALLEN ET HATFIELD (2004) par rapport au nombre total d'espèces locales et exotiques (sur la base de CLAPHAM et al. 1993.); Inde: JAIN & DEFILLIPPS (1991); Jordanie: ORAN ET ALI-EISAWI (1998); Népal: HAMILTON & RADFORD (2007); moyenne de plusieurs estimations, Pakistan: ZAHOR (1997); USA: MOERMAN (1996); Tous les autres pays: SCHIPMANN et al. (2006).

4 DISCUSSION

As the world's number of species is not exactly known (GOVAERTS 2001), it makes no sense to calculate the absolute number of MAP. The relative number is more correct and nevertheless impressive. Therefore, in the following, we only discuss the relative number.

The differences between some countries are striking: Calculated on a worldwide scale, every fifth plant can be regarded as MAP. This number matches that from Bulgaria, France and Germany. In countries like Benin, Burkina Faso, Korea, China and Pakistan, however, every third plant is or was used as MAP, whereas in countries like Hungary and the USA only every eighth plant can be regarded as MAP. This number drops even further for the Philippines or Malaysia where only every tenth or thirteenth plant can be attributed to medicinal or aromatic use. These differences might be due to various factors like:

- geographical position of the country,
- total species number of the country,
- importance of folk medicine and in the level of transmission of traditional knowledge,
- intensity of the ethnobotanical research,
- level of the standard of the sources used for the review.

A geographical component of the results is obvious: in most cases geographically close countries show similar percentages (difference < 5 %) of MAP, as Benin and Burkina Faso, China and Korea, France and Germany, India and Sri Lanka, or Malaysia and the Philippines. As explained below, the difference between China and India shown in Table 1 is a result of differences in the standard of the source. Considering sources of equal standard, i.e. the referring volumes of the series "medicinal plants of the world", the figures for China (DUKE & AYENSU 1985: 15.3 %) and India (JAIN & DEFILLIPS 1981: 16.1 %), these countries show a difference < 1 %. The highest difference found between neighbouring countries under equal standards is 2.4 %. Furthermore a second geographical relation can be stated: Four of the five countries with a percentage of MAP > 30 are entirely or partially situated in semiarid to arid regions, whereas the countries of temperate regions (except of Hungary and the USA; for potential reasons see below) show a range between 19.2 % and 26.7 %.

In contrast to the locally obtained results of SALICK et al. (1999), a correlation between the total number of species and the fraction of those used as MAP cannot be confirmed: China, for example, amongst the countries considered ranks with respect to total species number highest, while the relative use of MAP ranks China at position four. The country with the second highest species number (USA), however, ranks third before last on this list. Malaysia, where the relative use of MAP is the smallest, ranks on position number four on the list of total species numbers. Nearly the opposite is true for Burkina Faso, which is poor in total plant species, but leading for MAP-use with a relative portion of 35.2 %. Hungary, showing a similar low number of species in total is the fourth before last on the list of percentages of MAP (12.2 %).

For the USA, the low percentage of MAP can be explained historically: The European settlers, the main founding community of today's American population, did not know the plant species of their new home country. They brought along those MAP they new as especially important from Europe. The knowledge of the indigenous nations primarily was not considered. With the diminishing of the native people and extinction of whole ethnics groups necessarily a part of their knowledge on MAP got irretrievably lost and cannot even be rediscovered by the large data base established by MOERMAN (1996).

The countries with percentage of MAP > 30 % (Benin, Burkina Faso, P.R.China, Republic of Korea, Pakistan) have another feature in common: they belong either entirely (Burkina Faso, Benin) or at least in their rural areas to the poorest countries of the world so that it is (was) impossible for the majority of the people to buy "modern" MAP. In those countries the number of traditional healers outnumbers largely the number of modern doctors (HUMAN DEVELOPMENT REPORT 1990). Therefore, the tradition of folk medicine was maintained until today. Additionally, China, Korea and partially Pakistan have a very old and well documented tradition of folk medicine. Due to this documentation even in areas where today "modern MAP" are used, the knowledge was not lost. However, these arguments do not explain why China, Korea and Pakistan are so distinctive from Jordania, India, Nepal, Sri Lanka, Thailand and Vietnam.

In the European countries, which have an intermediate position in the ranking of the percentage of MAP, written records exist as well. However, the documents are not as old as in China so it cannot be excluded that some information was lost in the course of time. Malaysia and the Philippines have no written records on the traditions of folk medicine. Today, large parts of the population are concentrated in megalopolises where traditions probably get lost. For the rural areas it can be assumed that medicinal knowledge has not been documented to such an extent as in Burkina Faso, China and Korea.

In neighboring countries or regions, which differ with respect to a more arid or a more humid climate (Burkina Faso/Benin and northern China/southern China), for the arid country (region) more MAPs are reported than for the humid one. In China, the average MAP fraction of 36.2 % (YANG 2002) is unequally distributed between the humid south and the dry northwest: In the semiarid province of Qinghai 58.6 % of the species of vascular plants are used as MAP, in the humid province of Yunnan only 21.2 %. As these numbers stem from the same authors (SHENGJI et al. 2006), one can be sure that this difference is not a result of different methods or different standards. Furthermore, the figure for Qinghai is confirmed by the referring percentage of 58.9 % for the Autonomous Region of Ningxia (XING 2006), also belonging to the semi-arid region of China.

Some possible explanations for this fact are:

- In years of extreme dryness certain species totally drop out of the plant inventory, some get scarce (for example when cattle turns to devour plants usually avoided when the food supply is more abundant and diverse, some species are even hard to find). Therefore, in regions of po-

tential dry periods, it is essential to know some species, which can be used as substituent when the most effective medical plant species is not available. In areas of a balanced climate, particularly in the core tropics, there is no danger of species dropping out by climatic reasons. In such countries it is sufficient to know only the most effective MAP for a particular malady.

- In the humid tropics the species number is much higher than in arid regions. Therefore, assuming that a certain number of species is needed to fill all therapeutic demands (see e.g. ALENCAR et al. 2009), in the humid tropics the proportion of medicinal plants should be smaller than in arid areas.
- In arid and semiarid regions, pasture pressure on plants is higher than in humid areas. For this reason, plant species have to develop means of defense against being devoured, e.g. phenolics (TUOMI et al. 1991, HARTLEY & LAWTON 1991), and especially those are important sources of MAP (e.g. FERNANDES et al. 2009, HUANG et al. 2010).
- Under conditions of drought, cells accumulate sugar, abscisic acid and some particular alkaline proteins (HSIAO 1973). Although these substances are not particularly known as medicinally active, one cannot exclude that a combined effect of them may be of medicinal efficiency (e.g. GENG et al. 2001).
- Often the roots of plants are the basis of MAP, but even plants of the same species tend to show stronger root growth and or an increased shoot/root ratio in dry habitats (KUTSCHERA 1960).

A very important reason for the difference between neighboring countries is the standard of the source. This can differ in the following items:

- Threshold for species mentioned: are all species listed that have been used as medicinal plants or only those which appear to be worth of an industrial use or of a world wide trade ?
- Completeness of the survey: were all areas of the country considered ?
- Intensity of the survey: Most healers are very suspicious against strangers, in particular foreigners. It needs a long time (at least some weeks, often some months or even years) to get their confidence. Therefore, a country wide survey based on short visits of experts will result in a much lower number of MAP than a survey with long lasting stays in the areas under investigation.

The different numbers given for China by DUKE & AYENSU (1985: 15.3 %) and by YANG (2002: 36.2 %) witness the importance of the source: The first authors contribute to a volume of the series Medicinal Plants of the World which considers only species of more or less world wide interest, while the latter author has tried to summarize all information and has considered even species only rarely used. These findings solve the above mentioned contradiction of a highly different percentage of MAP in the neighboring countries China and India. For India we found no local source and therefore had to use the respective volume of Medicinal

Plants of the World (JAIN & DEFILLIPPS 1991). If we consider this series for both countries, we find rather identical percentages (China: 15.3 %; India: 16.1 %). Vice versa we postulate that the “real” number of MAP for India also resembles that one of China, i.e amounts to about 35 %.

Another striking example for the importance of the source is Benin: without own field research we would have to rely on the “official” list of Benin’s MAP (ADJANOHOON et al. 1989), which contains 507 species representing only 18.1 % of the flora. This number was found by an officially announced expert group that visited every province for three or four days. In contrast, our investigator (Siegstetter) stayed three times for three months in an area consisting of three villages and carried out his ethnobotanical research during the second and third stay, while the first stay was used to become acquainted with local people and to obtain their confidence. Since percentages given in Table 1 for Malaysia, The Philippines, Sri Lanka and Thailand also originate from overviews or short-surveys, but not from intensive long-lasting ethnobotanical research, they also can be estimated as an underrepresentation. Additionally, at least for some of the countries showing low values in Table 1, it is fair to assume that not all remote areas are investigated in detail.

5 CONCLUSION

For many countries the percentage given for MAP in literature is to low. But even using these low values every fifth vascular plant species is or was used as MAP. In tropical countries, particularly in semiarid regions, even every third species was used. The example of northern China shows that even every second species might represent a MAP. Assuming that plants in regions of equal ecological character have more or less the equal traits, we can conclude that in (semi)arid regions the average percentage of MAP amounts to about 35 %, while in temperate regions it reaches about 22 %. This assumption leads to a world-wide percentage of 25 to 30 %, i.e. every third or fourth plant species is a MAP. But, no matter whether we take this assumption as reality or if we rely on the published data shown in Table 1, the number of MAP is higher than estimated up to now. It represents a striking argument for the importance of a world-wide conservation of biodiversity.

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ADDRESSES OF THE AUTHORS:

Prof. Dr. Theo Dingermann¹, Dr. Karen Hahn^{2,3}, Dr. Robert Sieglstetter², Prof. Dr. Adjima Thiombiano⁴, Prof. Dr. Rüdiger Wittig^{*2,5} and Prof. Dr. Yingzhong Xie⁶

¹ Institute for Pharmaceutical Biology, Goethe-University, 60438 Frankfurt, Germany

² Abteilung Ökologie und Geobotanik. Institut für Ökologie, Evolution und Diversität, Goethe-Universität, 60323 Frankfurt, Germany

³ Zentrum für interdisziplinäre Afrikaforschung (ZIAF), Goethe-Universität, 60323 Frankfurt, Germany

⁴ Sciences de la Vie et de la Terre, Laboratoire de Biologie et Ecologie Végétales, Université de Ouagadougou, 03 BP 7021 Ouagadougou, Burkina Faso

⁵ Biodiversitäts- und Klima-Forschungszentrum (BiK-F), 60325 Frankfurt, Germany

⁶ Institute of Grassland Sciences, Ningxia University, China

* Corresponding author; e-mail: r.wittig@bio.uni-frankfurt.de

A university campus in peri-urban Accra (Ghana) as a haven for dry-forest species

Dietmar Simmering, Solomon Addai, Gunther Geller, Annette Otte

Summary: Valley View University (VUU) is a private university located within the dry forest zone of the Accra plains; an area strongly affected by urban sprawl. The campus covers approx. 105 ha. Considerable portions of it are yet undeveloped and covered with savannah thickets. In 2002, the university has committed itself to become Africa's first 'ecological university'. In the context of two projects, substantial improvements have been made in terms of sanitation, water supply, energy-saving buildings and organic agriculture. The further development of the campus was designed in a detailed 'ecological masterplan'. In this context, we carried out a floristic inventory of the savannah thickets and found more than 100 plant species; the majority of which represent the species pool of the unique mixture of dry forest and savannah thicket species, which is typical for the region. As the remainder of dry forests and savannah thickets in the Accra plains become increasingly threatened by urban sprawl and overgrazing, the VUU administration has agreed to preserve the species-rich thickets. This is a valuable contribution to a more sustainable development of the region.

Key words: dry-forest vegetation, green campus, land use change, species diversity, sustainable development, Sub-Saharan Africa.

UN CAMPUS UNIVERSITAIRE DANS LA ZONE PÉRI-URBAINE D'ACCRA (GHANA) COMME UN REFUGE POUR LES ESPÈCES DE FORÊT SÈCHE

Résumé: Valley View University (VUU) est une université privée située dans la zone de forêt sèche des plaines d'Accra; une zone fortement affectée par l'expansion urbaine. Le campus couvre approximativement 105 ha. Des parties importantes de celui-ci sont encore peu développées et couvertes de fourrées de savane. En 2002, l'université s'est engagée à devenir la première «université écologique» d'Afrique. Dans le cadre de deux projets, des améliorations substantielles ont été apportées en matière d'assainissement, d'approvisionnement en eau, de bâtiments peu consommateurs d'énergie et d'agriculture biologique. Le développement ultérieur du campus a été conçu dans un «schéma directeur écologique» détaillé. C'est dans ce contexte, que nous avons réalisé un inventaire floristique des fourrées de savane et avons trouvé plus de 100 espèces végétales; dont la majorité représente le pool est composé uniquement d'espèces de forêt sèche et de fourrées de savane, typiques à la région. Comme le reste des forêts sèches et des fourrés de savane des plaines d'Accra deviennent de plus en plus menacées par l'expansion urbaine et le surpâturage, l'administration VUU a accepté de préserver les fourrés riches en espèces. C'est une précieuse contribution à un développement plus durable de la région.

Mots clés: Végétation de forêt sèche, campus vert, mode d'utilisation des terres, diversité spécifique, développement durable, Afrique sub-saharienne.

EIN UNIVERSITÄTSGELÄNDE IM PERI-URBANEN ACCRA (GHANA) ALS EIN REFUGIUM FÜR TROCKENWALD-ARTEN

Zusammenfassung: Die Valley-View Universität (VUU) ist eine private Universität, die in der Trockenwaldzone der Accra Plains liegt; einem Gebiet, welches sehr stark von Urbanisierung und Zersiedlung betroffen ist. Das Campus-Gelände umfasst ca. 105 ha. Beachtliche Flächen davon sind bislang nicht bebaut und noch mit Savannengebüschen bedeckt. Im Jahre 2002 hat sich die VUU zum Ziel gesetzt, die erste „ökologische Universität“ Afrikas zu werden. Im Rahmen zweier Projekte wurden bedeutende Fortschritte im Abwassersystem und der Wasserversorgung sowie beim Bau energiesparender Gebäude und der ökologischen Landwirtschaft erzielt. Die weitere konzeptionelle Entwicklung des Campus wurde in einem detaillierten „Ökologischen Masterplan“ festgehalten. In diesem Rahmen führten wir eine floristische Bestandserhebung in den Savannengebüschen durch und fanden mehr als 100 Pflanzenarten. In der Mehrzahl handelte es sich dabei um den Artenpool der für die Region typischen Kombination aus Trockenwald- und Savannenarten. Da die verbliebenen Reste von Trockenwäldern und Savannengebüschen in den Accra Plains zunehmend durch (ungeplante) Zersiedlung und Überbeweidung bedroht sind, hat die VUU-Verwaltung sich bereit erklärt, die artenreichen Gebüsch auf dem Campus-Gelände zu erhalten. Sie leistet damit einen wertvollen Beitrag zu einer etwas nachhaltigeren Entwicklung der Region.

Schlagworte: Trockenwald-Vegetation, Grüner Campus, Landnutzungswandel, Artenvielfalt, nachhaltige Entwicklung, Sub-Sahara Afrika

1 INTRODUCTION

1.1 Peri-urban sprawl and human ecosystems

The increasing spread of peri-urban areas in the vicinity of metropolitan cities in many emerging and developing countries is often accompanied by social, societal and environmental problems (REDMAN & JONES 2005). Severe impacts on human welfare arise from the shortcomings in urban infrastructure and the accelerating environmental degradation, which are usually the results of unplanned, often illegal peri-urban spread. The negative impacts of unplanned, rapid urbanization are a consequence of the population growth due to migration from more remote rural areas, paired with ineffective urban gover-

nance. Already today, 50 % of the global population live in urban settings and the growth of peri-urban areas will expand to harbor 70% of the global population by 2050; and most urban growth will occur in developing and emerging countries (UNITED NATIONS 2010). Environmental and social problems related to the rapidly increasing urban sprawl are particularly evident in Sub-Saharan West Africa, such as around the major cities in Ghana (YANKSON & GOUGH 1999; GOUGH & YANKSON 2000; YEBOAH 2000, 2003; COBBINAH & AMOAKO 2013).

The land consumption in former rural areas due to these rapid urbanization processes leads to the exacerbation of land-use conflicts between agricultural needs and residential development, whereas both competing land-use types usually have also adverse effects on the biodiversity of natural (or semi-natural) habitats (VITOUSEK et al. 1997). In addition to improvements in urban governance and planning, enormous efforts are needed to make the necessary progress towards sustainable development of peri-urban environments and landscapes. Most urgently needed are solutions for the fundamental social and economic problems of urban sprawl, but the increasing negative impacts on the biodiversity of previously rural landscapes have to be simultaneously taken into account if the important ecological services and functions provided by natural and semi-natural habitats are not to be compromised.

The consideration of the ‘multifunctionality’ of landscapes aims to integrate ecological and economic aims of land use (OTTE et al. 2007; WALDHARDT et al. 2010). The concept also has potential to cope with the challenges of peri-urban development. According to SELMAN (2009) ‘land is capable of serving more than one purpose and of fulfilling several needs at the same time. Thus, on the same area of land, key functions – ecological, economic, sociocultural, and aesthetic – can be promoted simultaneously and to mutual benefit’. The simultaneous consideration of economic, environmental and cultural goals is without doubt challenging, but could be assured by the involvement of ecological knowledge and guidelines at all stages of planning and development of ‘human ecosystems’ (LYLE & WOODWARD 1999; STEPP et al. 2003; LOVELL & JOHNSTON 2009).

1.2 Ecological development at Valley View University

In this context, the aim of this paper is to report on a positive example of sustainable development. The highlighted ecological development of a university campus in Ghana includes the preservation of highly threatened, species-rich savannah thickets in a peri-urban environment.

The private Valley View University (VVU) is located in the peri-urban outskirts of Accra, capital of Ghana. The university, which is operated by the Seventh Day Adventists church, has a spacious property of 105 ha, which comprises settlement areas, public green space, large agricultural plantations, and larger parts of undeveloped ‘bushland’. Currently there are around 3,500 people working and studying on campus. This number is expected to grow up to 5.000 in a few years.

In 2002, the university has committed itself to become Africa’s first ‘ecological university’. In the context of two

projects funded by German Federal ministries from 2003 – 2010, concepts and various measures were developed, which improved the situation in terms of sanitation and water supply considerably and led to the construction of energy-saving green buildings and the implementation of organic agriculture on campus (GELLER et al. 2006, GERMER et al. 2006). By means of a detailed master plan, the entire campus was designed as a functional and sustainable ecosystem. Details on the design and concepts of these projects were recently published (GELLER & GLÜCKLICH 2012).

The main objective of our paper, however, is to report on the remarkable species diversity of the savannah thickets, which are part of the campus and which have to be viewed as one of the last remnants of this semi-natural habitat type in peri-urban Accra (Fig. 1). The preservation of these thickets has become an integral part of the ecological development of the campus.



Fig. 1: View from a lecture hall building over the extensive thickets on VVU campus; the Akwapim range in the background. / Vue d’une salle de cours de vastes fourrées sur le campus VVU / Blick von einem Universitätsgebäude über die ausgedehnten Savannengebüsche auf dem VVU-Campus; im Hintergrund der Akwapim-Höhenzug.

2 THE STUDY AREA

2.1 Location and Topography

Valley View University (VVU) (5.79°N, 0.12°W) is located 30 km from downtown Accra - just outside the borders of the Accra Metropolitan District (Fig. 2). The core city, the Accra Metropolitan District, has a population of 1.8 million, while the Greater Accra region is home to 2.9 million people. The Accra region is currently one of the fastest growing urban agglomerations in Africa with a growth rate of more than 3 % (UNITED NATIONS 2008).

The city is located in the so-called Accra plains. This lowland covers around 2,800 km² bordered by the Gulf of Guinea to the south, the Akwapim range in the northwest and the Volta River to the east. Here, it merges with the so called Dahomey Gap, which stretches further from SE-Togo to W-Nigeria. The topography is mostly flat to gently undulating. The altitude is around 80 m a.s.l. However, only a few kilometers to the west, the Akwapim range rises steeply to an elevation of 400 m.

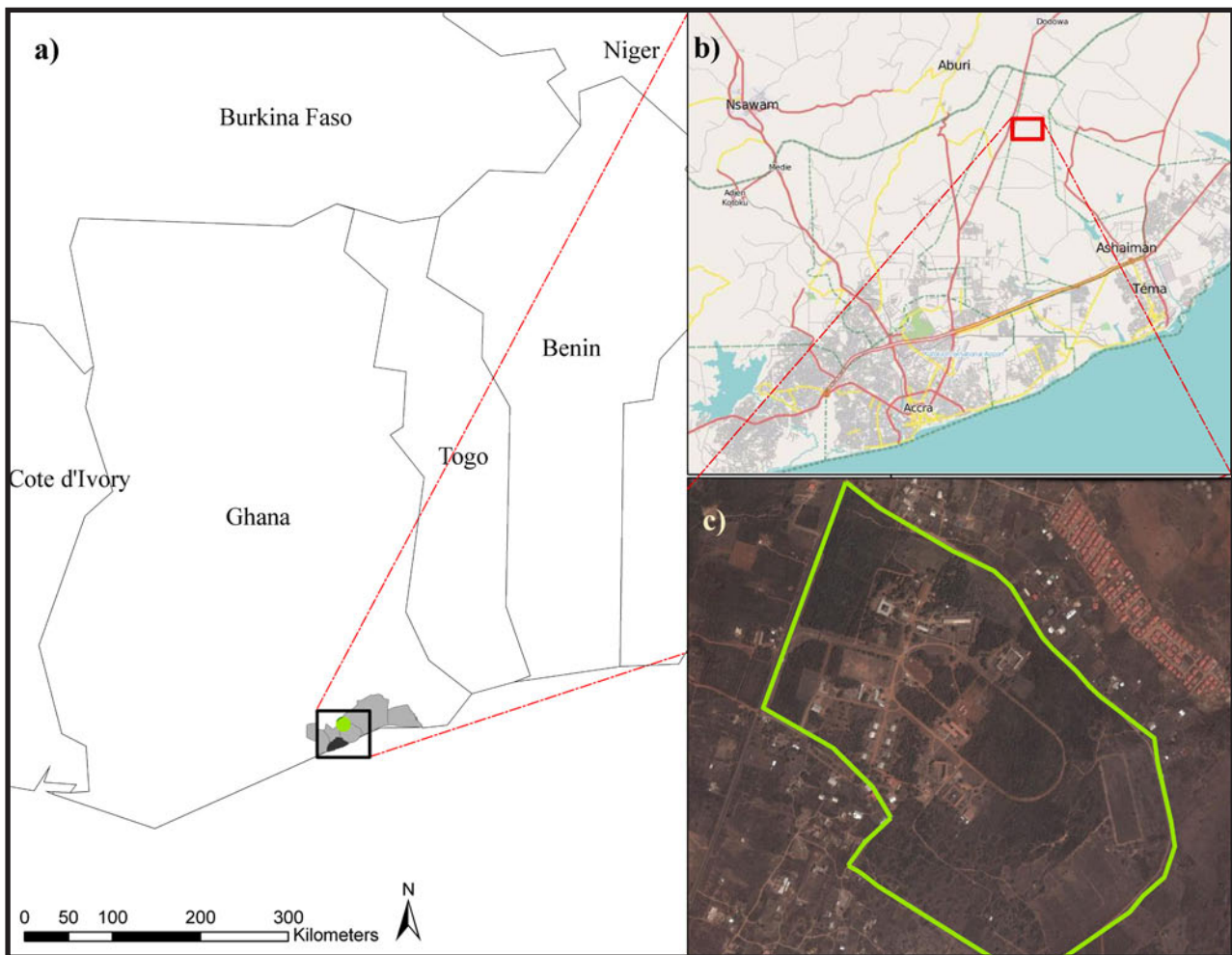


Fig. 2: Location of VVU in peri-urban Accra, Ghana. / Localisation de VVU dans la zone peri-urbaine d'Accra, Ghana / Lage der Valley View Universität im peri-urbanen Umfeld Accras (Ghana). /

- a) The Accra Metropolitan District (black) in the south of Ghana, and the Greater Accra Region (grey); b) The location of VVU on the road to Dodowa; c) VVU campus, the green line indicates the border of the property (neighboring fast developing residential housing areas). /
 a) Le distric metropolitan d'Accra (en noir) au sud du Ghana, et la grande région d'Accra (en gris); b) La localisation de VVU sur la route de Dodowa; c) Le campus VVU, la ligne verte indique la limite de la propriété (développement rapide contigu des zones résidentielles). /
 a) Der Accra-Metropol-Bezirk (schwarz) im Süden Ghanas und die „Greater Accra Region“ (schwarz); b) Die Lage der VVU an der Straße nach Dodowa, c) Der VVU-Campus, die grüne Linie zeigt die Grenze des Geländes (in der Nachbarschaft sich schnell ausbreitender Wohnsiedlungen).

2.2. Climate

The climate in the Plains is known as the Ghana dry zone or the Accra-Togo coastal climate. The Accra plains and the Dahomey Gap represent a discontinuity in the West African (Guinean) forest zone with unique climatic conditions. Accra receives only 780 mm rainfall, which is not sufficient to support rainforests typical of the neighboring Upper and Lower Guinea forest zones with rainfalls between 1300 – 5000 mm. To illustrate the steep climatic and ecological gradient: Aburi Botanical Garden, on the top of the Akwapim range and only 7 km away from VVU, receives 1,200 mm; VVU, in contrast, gets even less rain (700 mm) than Accra due to its location in the rain shadow of the Akwapim range.

The precipitation is distributed among the two rainy seasons (May – Mid-July, Mid-August – October) and falls often in short but intensive terms, which frequently causes local flooding. During the rainy season, monthly precipitation is between 50 and 150 mm. The period between December and

March is especially dry, with monthly total rainfall ranging from 0 to 50 mm. Despite this seasonality, the amount of rainfall is highly variable from year to year. The mean annual temperature is 26.5°C. Monthly averages range between 24.5 (August) and 28°C (March), and the average temperature during the day is 30°C. Humidity is high in general (65 - 95%), but is lower during the warmer months, particularly in January with its dry northeast 'harmattan' winds.

2.3 Natural and secondary vegetation

The Accra plains are an ancient cultural landscape, inhabited and formed by humans for 6,000 years. The dominating soils in the region are savannah ochrosols and regosolic groundwater laterites over acidic and basic Gneiss and Shists rocks (BRAMMER 1962). The reddish, brown and yellow sandy-to-loamy soils are generally shallow and prone to erosion. Organic matter content and nutrient status is low. However, plant growth is even more impeded by the poor physical properties of the droughty soils. Crops grown in the area without irrigation have to be drought resistant. There-

fore, a grassland savannah, traditionally grazed by cattle and regularly burned, is still the predominating vegetation and land-use type in the Accra plains.

Savannah grasslands and thickets were the most common vegetation types in this area prior to recent urbanization. However, the savannah in the Accra plains is considered a 'subclimax vegetation', a 'derived savannah'. The natural vegetation of the Accra plains is a dry semi-deciduous forest of various types, the most unique type being the "south-east outlier type" described by HALL & SWAINE (1976) from the nearby Shai Hills reserve. This forest type represents the driest extreme in Ghana. The vertical structure features a closed canopy composed of mainly *Millettia thonningii* and *Diospyros sp.* that reaches only 15 m in height, while *Dryopetes parviflora*, *Vepris heterophylla* and numerous savannah thicket and liana species form a 10 m understory. Ground cover is sparse. Scattered emergent trees tower up to 50 m above the canopy (*Ceiba pentandra*, among others). The remaining stands of this forest type are today restricted to scattered, very small reserves.

The original dry forest cover of the Accra plains has been turned into savanna by continuing human impact over the millennia. Regular burning, grazing, firewood cutting, charcoaling and rotation farming have maintained a savannah mosaic with varying proportions of grass and thicket cover. Regular disturbance prevents the development of forest.

2.4 Land-use history on VVU campus

The Valley View College, which was to become Valley View University in 1997, moved from a former urban location to its current site near the village of Oyibi in 1989. According to local traditions in land tenure, it was leased out for 99 years (OWUSU-MENSA 2009). At that time, the land was composed of savannah thickets and farmland, including fallow land. This pattern of land cover was typical for the rural areas surrounding Accra. Some parts of the property were at that time also still covered with tall Kyen-Kyen trees (Bark cloth tree, *Antiaris toxicaria* Lesh., Moraceae), which are characteristic for the native dry-forests of the Accra plains. Until the trees were felled in the 1990's, monkeys fed on them and inhabited the area, even after the university had opened the doors. However, at the beginning of the ecological projects in 2003, large areas of the property had not been managed at all, except for a few buildings, some roads and agricultural land. The 'bushland' was regarded by the students as hostile 'wilderness', whereas for rural dwellers the freely accessible land was an important source of firewood and charcoal, which was also regularly burned, and grazed by cattle.

3 METHODS

A floristic inventory of the savannah thickets at VVU was carried out in May 2009 with the support of experts on the Ghanaian flora. The species were photographed and specimens were collected for two herbaria stored at VVU and at Giessen University. The works of HUTCHINSON & DALZIEL (1954-1972), IRVINE (1961), ARBONNIER (2004) and HAWTHORNE & JONGKIND (2006) were used for plant identification. These references and LIEBERMAN (1982) were also

used to assign the plant functional type (tree, shrub, liana, herb, graminoid) and the Raunkiær Life forms. The phanerophytes were sub-grouped according to height as follows: nano- (less than 2m), micro- (2–8 m), meso- (8–30 m), and mega-phanerophytes (more than 30m).

Information on the rarity of medicinal plants was taken from ABBIW (no year, 1990). The evaluation of the conservation value was based on expert knowledge on the local distribution of plant species (Abbiw, pers. communication) as well as on literature review. Nomenclature follows the online 'African Plants Database' (2013), based and maintained at the Geneva Botanical Garden.

4 RESULTS AND DISCUSSION

4.1 Floristic survey and evaluation

In total, 108 plant species from 51 families were found in the thickets (Tab. 1). Families with more than three representatives were: Poaceae (9), Fabaceae (8), Rubiaceae (8), Euphorbiaceae (6) and Asclepiadiaceae (5).

However, the woody species of various families dominated the dense savannah thickets. Characteristic and frequent species were *Albizia zygia*, *Dialium guineense*, *Baphia nitida*, *B. pubescens*, *Gardenia ternata*, *Grewia carpinifolia*, *Griffonia simplicifolia*, *Lanea acida*, *Millettia thonningii*, *Paullinia pinnata*, *Philenoptera cyanescens*, *Sarcocephalus latifolius*, *Uvaria chamae*, *U. ovata*, *Tapinanthus globiferus*, *Zanthoxylum zanthoxyloides* (Fig. 3a-f).

Overall, we found 27 tree species, 26 shrub species, 26 lianas (including climbing shrubs, herbs and parasites), 18 (woody) herbs, and 11 graminoids. Phanerophytes represent the dominant life-form with 49 % of all species, the largest subgroup being medium sized shrubs and small trees (micro-phanerophytes, 2 - 8 m height) with 33 species (Fig. 4).

Ninety-six species have to be considered as native to the Accra plains and typical of the wooded savannahs in the Guinean zone, while 12 species are widespread tropical species that have become naturalized in the region. Among these are a number of invasive dominant species (see below). Many of the native species are traditionally used as medicinal plants. Twenty-seven species found in the thickets are regarded as 'endangered medicinal plants' on a regional scale. Most of them are rare due to habitat destruction and overexploitation for medicinal purposes (ABBIW 1990, no year).

The flora and vegetation of the thickets and grass savannah of the Accra plains have been studied by a number of authors. JENÍK & HALL (1976) state in their comprehensive phytosociological study that, although mainly comprised of species native to the Guinean zone, the grassland and thicket communities found in the Accra plains are unique in the context of tropical African vegetation. HALL & SWAINE (1976, 1981) reported the total remaining area of the typical dry-forest type of the plains at 20 km² in small scattered patches. It has to be assumed that, after 30 years of peri-urban development, this area is much smaller today. The authors also emphasize the structural and floristic distinctiveness of these forests, which is founded in the relative paucity of

Table 1: List of species found in the VVU-thickets / Liste des espèces trouvées dans les fourrées de VVU/ Artenliste der Savannengebüsche auf dem VVU-Campusgelände.

Abbreviations / Abbreviations / Abkürzungen:

PFT = Plant functional type / Type fonctionnel des plantes / Funktionelle Gruppe

LF = Life form type / Type biologique / Lebensform

Pinkwae = species occurring in the neighboring Pinkwae sacred-grove according to LIEBERMAN (1982) / Espèces se développant dans le voisinage de la grotte sacrée de Pinkwae selon LIEBERMAN (1982) / nach LIEBERMAN (1982) im benachbarten "Heiligen Hain" Pinkwae vorkommende Arten.

End. Med: endangered medicinal plants according to ABBIW (no year) / Plantes médicinales menacées selon ABBIW (sans date) / gefährdete Heilpflanzen nach ABBIW (ohne Jahr).

Inv. Species = non-native, invasive species / exotiques, espèces invasives / gebietsfremde, invasive Arten.

nn-P: nano-phanerophyte (< 2m), mc-P: micro-phanerophyte (2–8 m), ms-P: meso-phanerophyte (8–30 m), mg-phanerophyte (> 30m).

Name	Family	PFT	LF	Pinkwae	End. Med.	Inv. Species
<i>Ruspolia hypocrateriformis</i>	Acanth.	shrub	nn-P	x		
<i>Crinum ornatum</i>	Amaryllid.	herb	G	x		
<i>Scadoxus multiflorus</i>	Amaryllid.	herb	G	x		
<i>Lannea acida</i>	Anacardi.	tree	mc-P	x		
<i>Lannea barteri</i>	Anacardi.	tree	ms-P		x	
<i>Annona senegalensis</i>	Annon.	shrub	mc-P	x		
<i>Uvaria chamae</i>	Annon.	shrub	mc-P	x	x	
<i>Uvaria ovata</i>	Annon.	shrub	nn-P			
<i>Carissa spinarum</i>	Apocyn.	shrub	mc-P	x	x	
<i>Holarrhena floribunda</i>	Apocyn.	tree	ms-P			
<i>Hunteria umbellata</i>	Apocyn.	shrub	ms-P		x	
<i>Anchomanes difformis</i>	Arac.	herb	H, G	x		
<i>Cynanchum viminale</i>	Asclepiad.	liana	li	x		
<i>Gymnema sylvestre</i>	Asclepiad.	climbing shrub	mc-P, li		x	x
<i>Leptadenia hastata</i>	Asclepiad.	liana	li			
<i>Pergularia daemia</i>	Asclepiad.	climbing herb	T, li			
<i>Secamone afzelii</i>	Asclepiad.	liana	li	x	x	
<i>Asparagus warneckeii</i>	Asparag.	climbing herb	H, li	x		
<i>Chromolaena odorata</i>	Aster.	climbing herb	H, li			x
<i>Tridax procumbens</i>	Aster.	herb	T			x
<i>Vernonia colorata</i>	Aster.	shrub	mc-P	x		
<i>Adansonia digitata</i>	Bombac.	tree	mg-P	x		
<i>Ceiba pentandra</i>	Bombac.	tree	mg-P	x	x	
<i>Ehretia cymosa</i>	Boragin.	climbing shrub	mc-P, li	x		
<i>Dialium guineense</i>	Caesalpini.	tree	ms-P	x		
<i>Griffonia simplicifolia</i>	Caesalpini.	climbing shrub	mc-P, li	x		
<i>Senna occidentalis</i>	Caesalpini.	shrub	nn-P			
<i>Capparis erythrocarpos</i>	Cappar.	climbing shrub	mc-P, li	x	x	
<i>Gymnosporia senegalensis</i>	Celastr.	tree	mc-P	x	x	
<i>Gloriosa superba</i>	Colchic.	climbing herb	G, li			x
<i>Commelina erecta</i>	Commelin.	(subwoody) herb	H, C	x		
<i>Cnestis ferruginea</i>	Connar.	climbing shrub	mc-P, li			
<i>Rourea coccinea</i>	Connar.	shrub	nn-P	x	x	
<i>Evolvulus alsinoides</i>	Convolvul.	herb	H			
<i>Mariscus cylindristachyus</i>	Cyper.	graminoid	H			
<i>Scleria sp.</i>	Cyper.	graminoid	H			
<i>Dichapetalum madagascariense</i>	Dichapetal.	tree	ms-P			
<i>Dracaena surculosa</i>	Dracaen.	liana	li	x		

Name	Family	PFT	LF	Pinkwae	End. Med.	Inv. Species
<i>Sansevieria liberica</i>	Dracaen.	(subwoody) herb	H, C	x		
<i>Diospyros mespiliformis</i>	Eben.	tree	ms-P	x		
<i>Bridelia ferruginea</i>	Euphorbi.	tree	mc-P	x		
<i>Erythrococca anomala</i>	Euphorbi.	shrub	nn-P		x	
<i>Flueggea virosa</i>	Euphorbi.	shrub	mc-P			
<i>Jatropha gossypifolia</i>	Euphorbi.	shrub	nn-P	x		x
<i>Mallotus oppositifolius</i>	Euphorbi.	shrub	mc-P	x		
<i>Tragia benthamii</i>	Euphorbi.	shrub	mc-P	x		
<i>Abrus precatorius</i>	Fab.	liana	li	x	x	x
<i>Baphia nitida</i>	Fab.	tree	mc-P	x		
<i>Baphia pubescens</i>	Fab.	shrub	mc-P	x		
<i>Millettia thonningii</i>	Fab.	tree	ms-P	x		
<i>Philenoptera cyanescens</i>	Fab.	climbing shrub	mc-P, li	x		
<i>Pterocarpus erinaceus</i>	Fab.	tree	ms-P			
<i>Stylosanthes erecta</i>	Fab.	(subwoody) herb	H, C			
<i>Uraria picta</i>	Fab.	(subwoody) herb	H, C		x	
<i>Dovyalis sp.</i>	Flacourti.	shrub	nn-P			
<i>Flacourtia indica</i>	Flacourti.	shrub	mc-P	x		
<i>Hoslundia opposita</i>	Lami.	shrub	nn-P	x	x	
<i>Cassytha filiformis</i>	Laur.	herb (parasitic)	H, pa			
<i>Tapinanthus globiferus</i>	Loranth.	parasitic climber	li, pa			
<i>Acridocarpus smeathmanii</i>	Malphi.	climbing shrub	mc-P, li	x	x	
<i>Abutilon mauritianum</i>	Malv.	(subwoody) herb	H, C			
<i>Sida acuta</i>	Malv.	herb	T, H			x
<i>Sida linifolia</i>	Malv.	(subwoody) herb	H, C		x	
<i>Azadirachta indica</i>	Meli.	tree	ms-P	x		x
<i>Cissampelos mucronata</i>	Menisperm.	liana	li			
<i>Triclisia subcordata</i>	Menisperm.	liana	li	x		
<i>Albizia zygia</i>	Mimos.	tree	ms-P		x	
<i>Dichrostachys cinerea</i>	Mimos.	shrub	mc-P	x		
<i>Leucaena leucocephala</i>	Mimos.	tree	ms-P			x
<i>Antiaris toxicaria</i>	Mor.	tree	mg-P	x	x	
<i>Ochna membranacea</i>	Ochn.	tree	mc-P	x		
<i>Ximenia americana</i>	Olac.	tree	mc-P	x	x	
<i>Jasminum dichotomum</i>	Ole.	climbing shrub	mc-P, li			
<i>Eulophia cristata</i>	Orchid.	herb	G	x		
<i>Andropogon gayanus</i>	Poac.	graminoid	H			
<i>Chloris barbata</i>	Poac.	graminoid	T			
<i>Digitaria insularis</i>	Poac.	graminoid	H			x
<i>Eragrostis sp.</i>	Poac.	graminoid	H			
<i>Heteropogon contortus</i>	Poac.	graminoid	T	x		
<i>Oxytenanthera abyssinica</i>	Poac.	graminoid	ms-P			
<i>Panicum maximum</i>	Poac.	graminoid	H			
<i>Perotis hildebrandtii</i>	Poac.	graminoid	T			
<i>Sporobolus pyramidalis</i>	Poac.	graminoid	H			
<i>Talinum triangulare</i>	Portulac.	herb	H			x
<i>Crossopteryx febrifuga</i>	Rubi.	tree	mc-P			

Name	Family	PFT	LF	Pinkwae	End. Med.	Inv. Species
<i>Gardenia ternifolia</i>	Rubi.	shrub	mc-P	x		
<i>Morinda lucida</i>	Rubi.	tree	ms-P			
<i>Oxyanthus racemosus</i>	Rubi.	shrub	nn-P	x		
<i>Pavetta corymbosa</i>	Rubi.	shrub	nn-P	x		
<i>Psychotria sp.</i>	Rubi.	shrub	mc-P			
<i>Sarcocephalus latifolius</i>	Rubi.	climbing shrub	ms-P, li		x	
<i>Vangueriella spinosa</i>	Rubi.	shrub	mc-P	x		
<i>Afraegle paniculata</i>	Rut.	tree	ms-P	x	x	
<i>Clausena anisata</i>	Rut.	shrub	mc-P	x	x	
<i>Zanthoxylum zanthoxyloides</i>	Rut.	tree	ms-P	x	x	
<i>Allophylus africanus</i>	Sapind.	tree	mc-P			
<i>Deinbollia pinnata</i>	Sapind.	tree	mc-P			
<i>Paullinia pinnata</i>	Sapind.	liana	li	x	x	
<i>Pouteria alnifolia</i>	Sapot.	tree	mc-P	x		
<i>Scoparia dulcis</i>	Scrophulari.	(subwoody) herb	H, C		x	
<i>Schwenkia americana</i>	Solan.	herb	T, H			
<i>Waltheria indica</i>	Sterculi.	(subwoody) herb	H, C		x	
<i>Grewia carpinifolia</i>	Tili.	climbing shrub	mc-P, li	x		
<i>Trema domingensis</i>	Ulm.	shrub	ms-P			
<i>Lantana camara</i>	Verben.	climbing shrub	nn-P	x		x
<i>Premna quadrifolia</i>	Verben.	liana	li	x	x	
<i>Vitex doniana</i>	Verben.	tree	ms-P	x		
<i>Cissus sp.</i>	Vit.	liana	li			

species and high gregariousness among the trees, i.e. the local dominance of single species.

LIEBERMAN (1982) and LIEBERMAN & LI (1992) studied the ecology of the nearby dry forest of the Pinkwae Sacred Grove in Katamanso. In total, fifty species of trees, shrubs and lianas listed by LIEBERMAN (1982) for the Pinkwae forest were also found at VVU, indicating the high potential of the thickets to mature to a dry forest, when protected from cutting and burning (cf. Table 1). However, many of the recorded tree species in the VVU thickets were only found in small numbers and / or in juvenile or coppiced individuals. Full-grown trees did not occur at all for most species. This is a consequence of the unauthorized cattle grazing, firewood chopping and charcoaling by rural dwellers, and the frequent fires set by herdsmen and hunters.

Another threat to the species-rich thickets is the continuing spread of dominant introduced species, namely the Neem (*Azadirachta indica*) and Leucaena (*Leucaena leucocephala*) trees, as well as the noxious shrubby climbers Siam Weed (*Chromolaena odorata*) and Spanish Flag (*Lantana camara*). However, areas mainly occupied by these weeds were located in those areas destined for future development, whereas the 'bushland' containing mainly the Guinean savannah and dry-forest species were located in the destined "green belt" of the campus (Fig. 5).

Due to the increasing urban sprawl with ever-expanding residential areas and an associated overexploitation of natural resources (frequent burning, overgrazing), only very small portions of savannah bushland and natural vegetation are

today left in the former rural Accra region. Larger portions of relatively undisturbed savannah thickets and dry forest are only preserved in the mentioned Pinkwae Sacred Grove (Fig. 6) and in the Shai Hills Resource Reserve (Fig. 7). Since even these reserves are endangered by encroachment, the remaining thickets on the VVU campus are obviously very valuable in terms of biodiversity conservation at the regional scale.

4.2 Project outcome

Vegetation plays, without doubt, a crucial role in the functioning of human-dominated ecosystems and provides key benefits (ecosystem services) to the human population. The most fundamental of these 'ecosystem services' are the production of biomass as food and energy resource and the release of oxygen. But in human ecosystems, a well-developed plant cover also reduces heat, noise, dust, and serves as a wind break. Furthermore, it increases water infiltration and reduces runoff, thus facilitating flood control and groundwater recharge. Besides these more physical properties of vegetation and their effects on ecosystems, a quality green environment has numerous psychosocial benefits and promotes human wellbeing and health.

The first steps to account for the ecological functions and services provided by the vegetation in the eco-development of VVU were therefore the design of an extended, unspecified 'green belt' in the ecological master plan and the planting of various large tree orchards in the agricultural projects starting in 2003. The campus witnessed a rapid development

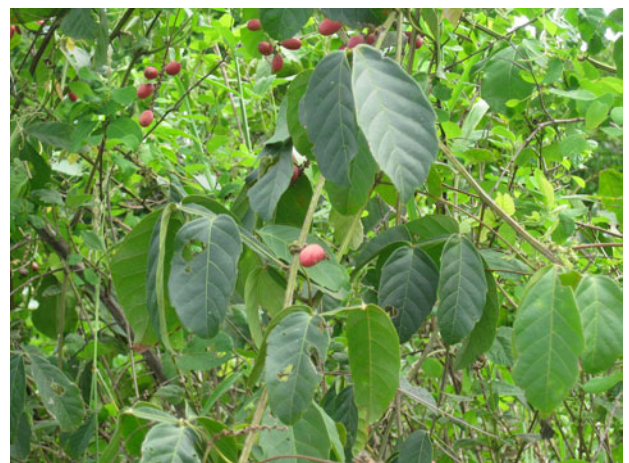


Fig. 3 a-f: Some characteristic species on VVU campus. / Quelques espèces caractéristiques du campus VVU / Einige charakteristische Arten der Gebüsche auf dem VVU-Gelände. a: *Millettia thonningii*, b: *Grewia carpinifolia*, c: *Sarcocephalus latifolius*, d: *Baphia nitida*, e: *Gardenia ternifolia*, f: *Paullinia pinnata*

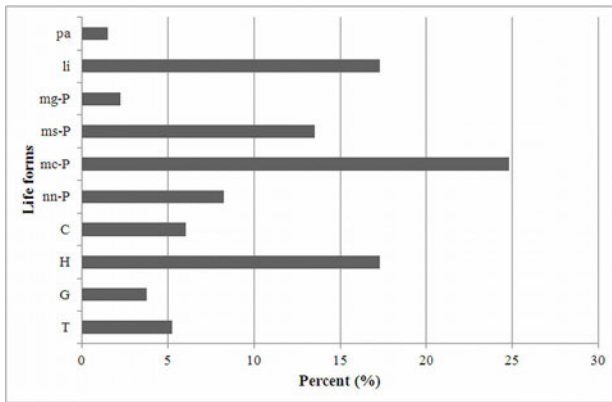


Fig. 4: Life-form spectrum of the thickets. Some species were assigned to more than one life form according to Tab. 1. / Spectre biologique des fourrés. Certaines espèces ont été assignées à plus d'une forme biologique selon le Tableau. 1. / Lebensformenspektrum der Savannengebüsche. Einige Arten wurden mehr als einer Lebensform zugeordnet (siehe Tab. 1).



Fig. 5: View into the dense thickets. Botanist R S. Amponsah collecting *Ochna membranacea*. / Vue des fourrés denses. Collection de *Ochna membranacea* d'un Botaniste R S. Amponsah. / Blick in das dichte Savannengebüsch. Botaniker R S. Amponsah sammelt *Ochna membranacea* für das Herbar.



Fig. 6: Satellite image of VVU and Pinkwae sacred grove. Image satellitaire de la grotte sacrée de VVU et Pinkwae

The distance between both sites is 4 km. The dark color indicates the thickets, both are surrounded by overgrazed / burned savannah and fast spreading residential areas. / La distance entre les deux sites est de 4 km. La couleur foncée indique les fourrés, les deux sont entourés par des zones surpâturées/ savane brûlée et expansion rapide des zones résidentielles / Satellitenbild des VVU-Geländes und des Heiligen Hains "Pinkwae" in etwa 4 km Entfernung. Die dunkle Farbe kennzeichnet die geschlossenen Gebüsche, beide Gebiete sind von überweideter / gebrannter Savanne und sich schnell ausbreitenden Wohnbebauungen umzingelt.



Fig. 7: The largest remaining dry-forest in the Accra plains: Shai Hills Resource Reserve (20 km northeast from VVU) with emergent Kapok (*Ceiba pentandra*) trees towering over the dense dry forest canopy with flowering *Millettia thonningii*. / Le plus grand vestige de forêt sèche dans les plaines d'Accra: Réserve de ressources du Mont Shai (20 Km au nord-est de VVU) avec des kapokiers (*Ceiba pentandra*) émergeant au-dessus de la canopée de la forêt sèche avec *Millettia thonningii* en floraison. / Der größte noch erhaltene Trockenwald in den Accra Plains: das Shai Hills-Schutzgebiet 20 km nordöstlich der VVU. Einzelne Kapokbäume (*Ceiba pentandra*) überragen die dichte Baum-schicht des Trockenwaldes mit blühenden *Millettia thonningii*.

of the university, and by 2008, 27 % of the total area were already covered with buildings and associated green space. Another 21 % were used for agriculture, 29 % were awaiting future development and approx. 12 % were reserved for the green belt. During a later stage of the project, the planting of a large numbers of trees (fruit trees, shade trees, ornamentals, but also native tree species in burned areas) was a major focus (GELLER & GLÜCKLICH 2012).

However, vegetation serves also as habitat for plant and animal species and is thus the foundation of biodiversity. The conservation of biodiversity and a wildlife-friendly management of the remaining semi-natural and natural habitats is therefore an important issue in rural and urban systems. This is particularly important for the last remnants of dry-forest and shrub vegetation in the Accra plains, which are known to harbor a considerable diversity of animal species (e.g., DECHER 1997, DECHER & BAHIAN 1999, CAMPBELL 2004).

From the results of the floristic survey, the intent evolved to protect 17 ha of the threatened species-rich bushland on VVU property (Fig. 8). Only slight modifications of the initial planning were necessary to permit the preservation of relevant thicket areas, without compromising the further development of the university according to the master plan.

In 2010, the VVU administration has therefore agreed to exempt the central parts of bushland from further development. In addition, the agricultural department at VVU takes measures for the protection of the thickets from unauthorized firewood chopping and burning. The preservation of the thickets is a significant contribution to preserve the unique mixture of dry-forest species in the Accra plains.

Acknowledgements

The authors dedicate this paper to the memory of our partner, Professor Dr.-Ing. Detlef Glücklich, who had been one of the creative minds behind the master plan for VVU. Sadly, he passed away in June 2013.

We cordially thank all people and institutions that were part of and supported the projects at Valley View University from 2003 – 2010. We are very grateful for the successful cooperation with the VVU administration. Foremost, we thank former VVU-president Dr. Seth Laryea and the former director of the Physical Plant, Emmanuel Kwandahor, for their enduring support and passion. The support of Prof. J. K. Osei was invaluable to compensate for lack of time in the tree-planting project. We are further indebted to the excellent botanists Daniel K. Abbiw, former curator of the University of Ghana herbarium, and his colleague R.S. Amponsah for their patient help in the field. The project (ZN IÖV Ghana 08_IL_023) was funded by the German Ministry for the Environment, Nature Conservation and Nuclear Safety within the International Climate Change Initiative (IKI).



Fig. 8: Designated preservation areas for thicket vegetation on VVU-campus. / Zone réservée à la conservation de la végétation de fourrée sur le campus VVU / Die vorgesehenen Schutzzonen für die Savannengebüsche auf dem VVU-Gelände.

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ADDRESSES OF THE AUTHORS

Prof Dr. Dr. Annette Otte*

Dr. Dietmar Simmering*

Division of Landscape Ecology and Landscape Planning, Justus-Liebig-University Giessen, IFZ, Heinrich-Buff Ring 26-32, D-35390 Giessen, Germany

E-Mail:

annette.otte@umwelt.uni-giessen.de

dietmar.simmering@umwelt.uni-giessen.de

* Authors to whom correspondence should be addressed:

Solomon Addai

Valley View University, Accra-Dodowa Rd. Mile 19 (near Oyibi), P.O. Box AF 595, Adenta, Ghana

Gunther Geller

Ecological Engineering Society (IÖV e.V.), Völkstraße 27, D-86150 Augsburg, Germany

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c/o Prof. Dr. R. Wittig
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Ökologie und Geobotanik
Siesmayerstraße 70 | Haus B
60323 Frankfurt/M.
Germany
eMail: r.wittig@bio.uni-frankfurt.de

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c/o Prof. Dr. R. Wittig
Institut für Ökologie, Evolution & Diversität
Ökologie und Geobotanik
Siesmayerstraße 70 | Haus B
60323 Frankfurt/M., Allemagne
eMail: r.wittig@bio.uni-frankfurt.de