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Research Article

# SACRED WOODLANDS AND BIODIVERSITY CONSERVATION IN BURKINA FASO (WEST AFRICA)

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**A B S T R A C T**

Nowadays, natural resources management based on modern methods of preservation has shown its limits, forcing managers to combine local practices and knowledge. This work based on ethnobotanical investigation and phytosociological surveys, has been undertaken in order to show the importance of sacred woodlands in biodiversity conservation and to provide reliable data on the flora and vegetation of sacred woodlands. The study was carried out in the four phytogeographical areas of Burkina Faso. Investigation allowed identifying 1206 sacred woodlands of which 403 have been the subject of extensive inventory to assess the level of biodiversity. 417 phytosociological surveys were carried out as part of floristic inventory. The data was analyzed by multivariate method using CAP, EXCEL 2010 and JMP9 software. The results of the floristic analysis show an important floristic richness of the sacred woodlands with 470 species belonging to 284 genera and 74 families, which represent 24. 54% of the national flora. The dominant species in sacred woodlands are mainly phanerophytes and therophytes. Chorology shows Sudanese species are predominant, followed by pantropical species and Sudano-Zanbesian species in almost all the four phytogeographical areas of Burkina Faso. Some very rare endangered species in surrounding areas have found in the sacred woodlands. This shows the need to take actions to safeguard biological diversity of sacred woodlands.



## INTRODUCTION

The growing degradation of natural resources has become a concern to environmentalists today looking for information, indicators and decision making support tools. Indeed, with the increasing degradation of natural resources during the second half of the twentieth century, there is a reinforcement of a vision according to which human actions are at the root of the disruption and destruction of ecosystems (Costanza, 2005). No country in the world escapes the problem of the destruction of environment and ecosystems, which mainly affects developing countries and particularly African states which are already struggling under the weight of various problems of their daily lives. In this context of degradation of anthropised ecosystems, protected areas are currently refuges for certain species (Sokpon *et al*., 1998; Sokpon and Agbo, 1999; Guinko *et al*. 2000; Kokou and Caballé 2000; Duchesme, 2002; Kokou *et al*., 2005; Kokou and Sokpon, 2006; Kokou and Kokutse, 2007; Mansourian *et al*., 2009).

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Protected forest areas help to preserve ecosystems that provide habitat, shelter, food, raw materials, genetic material, a barrier to natural disasters, a stable source of resources, and many other goods and services specific to ecosystem (Berkes and Davidson-Hunt, 2006; Adjonou *et al*., 2009; Mansourian *et al*., 2009; Aikpe and Tchibozo, 2010). This ecosystem diversity within protected areas could ensure the protection of species that are disappearing in the terroirs. The characterization of ecosystems and communities of species subservient to protected areas is fundamental to assess the importance of each protected area in maintaining and sustaining biodiversity (Ouédraogo, 2009). Indeed, according to Kent and Coker (2003) and Ouédraogo (2006), vegetation data are very useful in solving ecological problems, especially as a basis for predicting future possible changes. This opinion is supported by Mbaygone (2008) for whom the global floristic characteristics as well as the organization of phytocenoses are indicators of stability or degradation of an environment that can serve as an alert or decision-making tool for managers. Thus, Thiombiano (2005) specifies that the protection of resources against the various factors of degradation is only possible if each of the nations has a good knowledge of both the floristic diversity and the ecosystems itself. That is why

Vogiatzakis *et al*. (2006) consider that one of the major constraints for biological conservation is the limit of knowledge about the distribution of species and plant communities. Many authors have shown the importance of these protected areas, in particular the sacred woodlands, in the conservation of natural resources because of the customary authorities' control over the use of their natural resources (Guinko, 1984; Sow, 2003; Swami *et al*., 2003; Kokou and Kokutse, 2007; Savadogo, 2008; Savadogo *et al*., 2010; Fournier, 2011). By virtue of their protective function, these forests should remain free from destructive human intervention. If the flora and vegetation of Burkina Faso's conventional protected areas (parks, classified forest, reserves, experimental stations ...) are known thanks to the multiple efforts of some researchers (Ouoba, 1999; Taita, 1999; Kaboré, 2004; Ouédraogo, 2004; Da, 2006; Ouoba, 2006; Gnoumou, 2007; Mbanygone, 2008; Ouédraogo, 2009; Nacoulma *et al*., 2011), traditional protected areas such as sacred woodlands remain poorly known. Very few detailed floristic studies have been done on the sacred woodlands in the country. Existing studies to date have been limited to specific regions such as the center, east and north of the country (Ouadba, 2003; Thiombiano 2005; Savadogo, 2008; Savadogo *et al*., 2010). Only the work of Guinko (1984) on small samples has, through another approach, characterized the flora of some sacred woodlands in Burkina Faso. The sacred woodlands, which are dense plant formations, traditionally managed and protected by the local population for cultural purposes, could not be ignored as to their floristic compositions. This study aims to:

- inventory the flora of the sacred woodlands;
- appreciate their floristic diversity;
- look for refuge species within them.

The availability of accurate data on the flora and vegetation of sacred woodlands would serve as a reference tool for the orientation of management plans.

## MATERIALS AND METHODS

### *Study areas*

The study was carried out in Burkina Faso throughout the four phytogeographical sectors of the country. It covered 330 villages, 40 provinces and 13 regions. Guinko (1984), Fontès and Guinko (1995), distinguish two main areas or phytogeographical territories using climate, plant communities and flora: the Sahelian domain and the Sudanese domain, each of themis subdivided into two sectors (Fig 1):

- The strict Sahelian sector or northern Sahelian sector characterized by a maximum annual rainfall between 400 and 600 mm and a lot of Sahelian and Sahelian species dominated by thorny shrubs (Fontès and Guinko, 1995). Steppe vegetation occupies drier areas while thicket vegetation is spread onmore humid habitats temporarily flooded (Ouédraogo, 2006).
- The sub-Sahelian or southern Sahelian sector, which is an interference zone of many Sahelian species (Guinko, 1984). It corresponds to the sub-Sahelian climate zone, with a rainfall
- Between 600 and 750 mm (Fontès and Guinko, 1995). Vegetation is dominated by thickets, tiger bush and wooded savannahs.
- The northern Sudanese zone with annual maximum precipitation of 750 to 1000 mm (Fontès and Guinko, 1995). The savanna formations dominate the vegetation of this area, with a high frequency of tree and wooded facies (Ouédraogo, 2006).
- The southern Sudanese zone with annual precipitation exceeding 1000 mm (Fontès and Guinko, 1995). The vegetation is mainly dominated by wooded savannahs. Shrub savannahs are poorly represented. Forest formations are mostly linked to the presence of rivers (Ouédraogo, 2006).

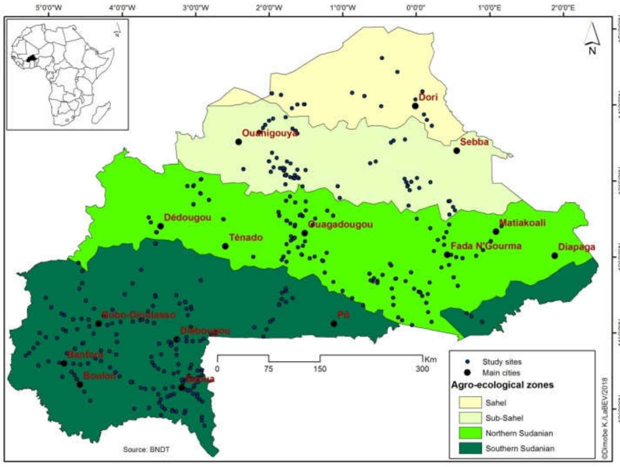


**Figure 1** Location map of the study sites

## METHODOLOGY

Floristic data were collected on 1206 sacred woodlands. Three plots of 1000 m² (50 m x 20 m) were established for the woody stratum (417 records) and 100 m² (10 m x 10 m) for the herbaceous stratum using stratified random sampling. The surveys were distributed as follows: 72 in the strict sahelian zone, 87 in the sub-sahelian zone, 116 in northern Sudanese and 142 in southern Sudanese.The classical phytosociological method of Braun-Blanquet (1932) was used: A list of all species present in the plot has been established and abundance-dominance was estimated. The scale of abundance-dominance used is that of Braun-Blanquet (Table 1).Vegetation types are described according to White classification (1986). The trees cover rates were estimated visually. The majority of the surveys were carried out at the optimum of the herbaceous vegetation (September to the end of October), which allowed collection of fertile plant samples for identification. Following documents were used for identification: Berhaut, 1976 and 1988; Le Bourgeois and Henri, 1995; Arbonier, 2000. If needed, plant samples were determined and verified by specialists at the herbarium of Ouaga I University Professor Joseph Ki-ZERBO. The scientific names of all plants have been validated by the International Plant Names Index database (IPNI, 2011).

The floristic richness was calculated for each sacred woodland. The life-form of each species was described according to Raunkjær (1934). The phytogeographic distributions were established for each species according to the major chorological subdivisions established for Africa (White, 1986). Raw spectra were used to demonstrate the abundance of each life form type or chorological type. Species richness was calculated using the Shannon and Weaver (1949) index to characterize plant formations in sacred woodlands. Specific diversity is defined as the total number of species and individuals (abundance) in a given group. It can also be evaluated by the Shannon index (Kent and Cooker, 2003) according to the formula:

$$H' = -\sum_{i=1}^{S} \frac{ni}{N} \log 2 \frac{ni}{N}$$

H '= Shannon index, ni = average recovery of species i in the group; N = sum of all recoveries of all species constituting the group; log = logarithm of Neperian, S = total number of species constituting the group.

The value of Shannon's diversity varies from 0 to logS. It tends to 0 when the group is less diversified (contains very few species); It is maximum when the number of species is high. The Student test at the 0.05 threshold was carried out with the JMP9 software to compare the floristic richness of the sites according to the climatic gradient.

## RESULTS

A total of 470 species, belonging to 284 genera and 74 families were found in 417 surveys spread throughout the 4 phytogeographical sectors. Tables1 and 2 show the distribution of this flora by phytogeographic zone. There is a significant increase in the diversity (species, genus and family) from the Sahel to the southern Sudanese. However, some species, families, and genera can be found in the sub-Sahel, northern Sudanese, and southern Sudanese. Only the species of the strict Sahel are specific to this sector; and are only encountered in this sector.

**Table 1** Floristic composition of sacred woodlands in the 4 phytogeographic zones of Burkina Faso

| | Species | Genus | Family |
|---|---|---|---|
| Sahel | 89 | 64 | 30 |
| Sub-sahel | 180 | 130 | 48 |
| North sudanese | 217 | 155 | 59 |
| South sudanese | 344 | 230 | 74 |

Most species occurred in two or three zones (Fig2). These distributions show the existence of a floristic specificity and a floristic contiguity between neighboring phytogeographical sectors.

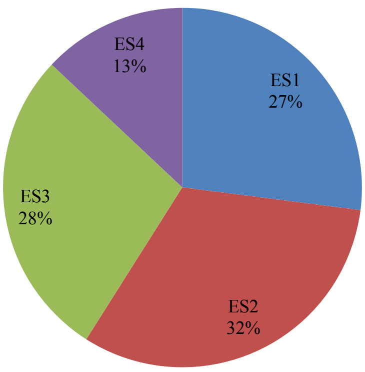


**Figure 2** Proportion of species present in one, two, three or four zones

ES1: species present in only 1 sector; ES2: species present only in two sectors; ES3: species present only in three sectors; ES4: species present in all four sectors

Species confined to a single zone are mainly found in the southern Sudanese zone (Fig3). These include, among others, Trema orientalis, *Spondias monbin, Quassia undulata, Oncoba spinosa, Elaeis guineensis, Eriosema molle, Eleocharis complanata, Gymnema sylvestre, Haematostaphis barteri, Indigofera capitata, Indigofera polysphaera, Kigelia africana, Psychotria psychotrioides, Strophantus sarmentosus, Swartzia madagascariensis, Tephrosia Brevigera, Tricalysia okelensi, Zanthoxylum zanthoxyloides.* The strict sahel sector presents barely 5% of its own species. Among these species are *Euphorbia balsamifera*, *Acacia tortilis*.

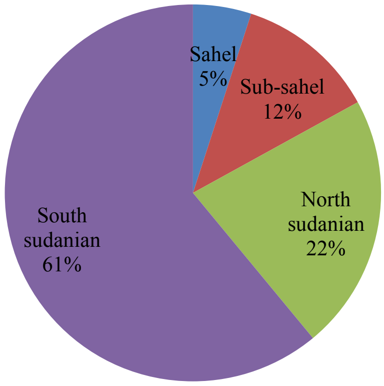


**Figure 3** proportion of species confined to one phytogeographic zone

Floristic richness and diversity (Shannon index) varied significantly among zones and increased from Sahel to the south Sudanese zone (Table 4).

The richness and the floristic diversity of sacred woodlands vary following the 4 phyogeographic sectors. The southern Sudanese zone recorder the most floristic richness (table 3).

***Life form and chorological types of species***

In all the 4 phytogeographical zones, the therophytes and phanerophytes are the predominant biological types (Fig 4). Geophytes and hemicryptophytes are poorly represented, while epiphytes are very few. There are more phanerophytes in the sacred woodlands of south Sudanese sector than in those of the other 3 sectors. The proportion of therophytes in the sacred woodlands of south Sudanese sector is much lower than those of the sacred woodlands therophytes in other zones. In the north Sudanese and south Sudanese sectors, there are more phanerophytes than therophytes.

**Table 2** Family diversity in genera and species according to phytogeographic zones

| Family | Sahel strict | | | Sub-sahel | | | Northern sudanese | | | Southern sudanese | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Genera | Species | % of species | Genera | Species | % of species | Genera | Species | % of species | Genera | Species | % of species |
| Acanthaceae | 2 | 2 | 2.24 | 1 | 1 | 0.55 | 3 | 3 | 1.38 | 4 | 4 | 1.16 |
| Agavaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Aizoaceae | 1 | 1 | 1.12 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Amaranthaceae | 3 | 3 | 3.37 | 5 | 5 | 2.77 | 4 | 4 | 1.84 | 5 | 7 | 2.03 |
| Anacardiaceae | 1 | 1 | 1.12 | 3 | 5 | 2.77 | 4 | 6 | 2.76 | 3 | 5 | 1.45 |
| Anonaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Apocynaceae | 0 | 0 | 0 | 3 | 3 | 1.66 | 2 | 2 | 0.92 | 5 | 7 | 2.03 |
| Araceae | 1 | 1 | 1.12 | 1 | 1 | 0.55 | 1 | 2 | 0.92 | 2 | 3 | 0.87 |
| Arecaceae | 1 | 1 | 1.12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Asclepiadaceae | 0 | 0 | 0 | 4 | 4 | 2.22 | 3 | 3 | 1.38 | 8 | 9 | 2.61 |
| Asteraceae | 1 | 1 | 1.12 | 4 | 4 | 2.22 | 4 | 4 | 1.84 | 5 | 6 | 1.74 |
| Balanitaceae | 1 | 1 | 1.12 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Bignoniaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 2 | 2 | 0.58 |
| Bixaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 2 | 0.58 |
| Bombacaceae | 1 | 1 | 1.12 | 2 | 2 | 1.11 | 2 | 2 | 0.92 | 3 | 3 | 0.87 |
| Boraginaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Burseraceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 7 | 13 | 5.99 | 1 | 1 | 0.29 |
| Caesalpiniaceae | 3 | 7 | 7.86 | 8 | 16 | 8.88 | 2 | 2 | 0.92 | 10 | 17 | 4.94 |
| Capparidaceae | 2 | 2 | 2.24 | 4 | 4 | 2.22 | 1 | 1 | 0.46 | 2 | 3 | 0.87 |
| Caryophyllaceaeeee | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 4.60 | 1 | 1 | 0.29 |
| Celastraceae | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 2.76 | 1 | 1 | 0.29 |
| Chrysobalanaceaeeeee | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0.92 | 1 | 1 | 0.29 |
| Clusiaceae | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0.92 | 1 | 1 | 0.29 |
| Combretaceae | 2 | 5 | 5.61 | 4 | 9 | 5.00 | 2 | 2 | 0.92 | 5 | 13 | 3.77 |
| Commelinaceae | 3 | 3 | 3.37 | 3 | 3 | 1.66 | 1 | 1 | 0.46 | 4 | 6 | 1.74 |
| Convolvulaceae | 0 | 0 | 0 | 1 | 2 | 1.11 | 6 | 9 | 4.14 | 4 | 7 | 2.03 |
| Cucurbitaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 11 | 18 | 8.29 | 1 | 1 | 0.29 |
| Cyperaceae | 0 | 0 | 0 | 1 | 2 | 1.11 | 1 | 1 | 0.46 | 5 | 9 | 2.61 |
| Dioscoreaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 1 | 2 | 0.58 |
| Dipterocarpaceae | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1.38 | 1 | 1 | 0.29 |
| Ebenaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 4 | 4 | 1.84 | 1 | 1 | 0.29 |
| Euphorbiaceae | 1 | 1 | 1.12 | 5 | 7 | 3.88 | 1 | 1 | 0.46 | 8 | 10 | 2.90 |
| Fabaceae | 4 | 7 | 7.86 | 9 | 13 | 7.22 | 2 | 2 | 0.92 | 12 | 30 | 8.72 |
| Flacourtiaceae | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 1.84 | 2 | 2 | 0.58 |
| Hymenocardiaceae | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1.38 | 1 | 1 | 029 |
| Hypocrateaceae | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 14 | 6.45 | 1 | 1 | 0.29 |
| Lamiaceae | 0 | 0 | 0 | 2 | 2 | 1.11 | 4 | 4 | 1.84 | 7 | 8 | 2.32 |
| Liliaceae | 1 | 1 | 1.12 | 4 | 4 | 2.22 | 1 | 1 | 0.46 | 5 | 6 | 1.74 |
| Loganiaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 1 | 2 | 0.92 | 2 | 3 | 0.87 |
| Loranthaceae | 2 | 2 | 2.24 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 2 | 3 | 0.87 |
| Malvaceae | 1 | 3 | 3.37 | 2 | 4 | 2.22 | 1 | 1 | 0.46 | 1 | 3 | 0.87 |
| Meliaceae | 1 | 1 | 1.12 | 2 | 2 | 1.11 | 1 | 1 | 0.46 | 3 | 3 | 0.87 |
| Mimosaceae | 2 | 9 | 10.11 | 6 | 13 | 7.22 | 21 | 32 | 14.74 | 8 | 18 | 5.23 |
| Molluginaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Moraceae | 0 | 0 | 0 | 3 | 3 | 1.66 | 1 | 1 | 0.46 | 2 | 7 | 2.03 |
| Myrtaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.46 | 2 | 2 | 0.58 |
| Nyctagynaceae | 0 | 0 | 0 | 2 | 2 | 1.11 | 1 | 1 | 0.46 | 1 | 2 | 0.58 |
| Nympheaceae | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 10 | 4.60 | 1 | 2 | 0.58 |
| Ochnaceae | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0.92 | 1 | 1 | 0.29 |
| Olacaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 2 | 2 | 0.92 | 1 | 1 | 0.29 |
| Onagraceae | 1 | 1 | 1.12 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 3 | 0.87 |
| Oxalidaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0.92 | 1 | 1 | 0.29 |
| Pedaliaceae | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1.38 | 1 | 1 | 0.29 |
| Poaceae | 15 | 19 | 21.34 | 16 | 23 | 12.77 | 1 | 1 | 0.46 | 28 | 42 | 12.20 |
| Polygalaceae | 1 | 1 | 1.12 | 0 | 0 | 0 | 3 | 9 | 4.14 | 1 | 1 | 0.29 |
| Pondeteriaceae | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0.92 | 1 | 1 | 0.29 |
| Portulacaceae | 0 | 0 | 0 | 2 | 2 | 1.11 | 4 | 4 | 1.84 | 1 | 1 | 0.29 |
| Rhamnaceae | 1 | 1 | 1.12 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 1 | 2 | 0.58 |
| Rubiaceae | 3 | 4 | 4.49 | 5 | 9 | 5.00 | 1 | 1 | 0.46 | 15 | 20 | 5.81 |
| Rutaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.46 | 1 | 1 | 0.29 |
| Sapindaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 0 | 0 | 0 | 5 | 5 | 1.45 |
| Sapotaceae | 0 | 0 | 0 | 2 | 2 | 1.11 | 0 | 0 | 0 | 4 | 4 | 1.16 |
| Scrophyllariaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Simaroubaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Smilacaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Solanaceae | 1 | 1 | 1.12 | 1 | 2 | 1.11 | 0 | 0 | 0 | 3 | 3 | 0.87 |
| Sterculiaceae | 2 | 2 | 2.24 | 3 | 3 | 1.66 | 0 | 0 | 0 | 5 | 6 | 1.74 |
| Taccaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Tiliaceae | 2 | 2 | 2.24 | 3 | 9 | 5.00 | 0 | 0 | 0 | 3 | 10 | 2.90 |
| Ulmaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 0 | 0 | 0 | 1 | 1 | 0.29 |
| Verbenaceae | 0 | 0 | 0 | 1 | 1 | 0.55 | 0 | 0 | 0 | 5 | 7 | 2.03 |
| Vitaceae | 0 | 0 | 0 | 2 | 2 | 1.11 | 0 | 0 | 0 | 2 | 5 | 1.45 |
| Zingiberaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0.58 |
| Zygophyllaceae | 1 | 1 | 1.12 | 1 | 1 | 0.55 | 1 | 1 | 0.46 | 0 | 0 | 0 |

**Table 3** Richness and diversity of 100 $m^2$ plots in sacred woodlands in four zones

| Phytogeographic zone | Average of floristic richness | Average of diversity (& diversity) |
|---|---|---|
| Sahel | 16.42 | 1.6 |
| Sub-sahel | 23.73 | 2.3 |
| Northern sudanese | 27.62 | 3.05 |
| Southern sudanese | 37.69 | 3.82 |

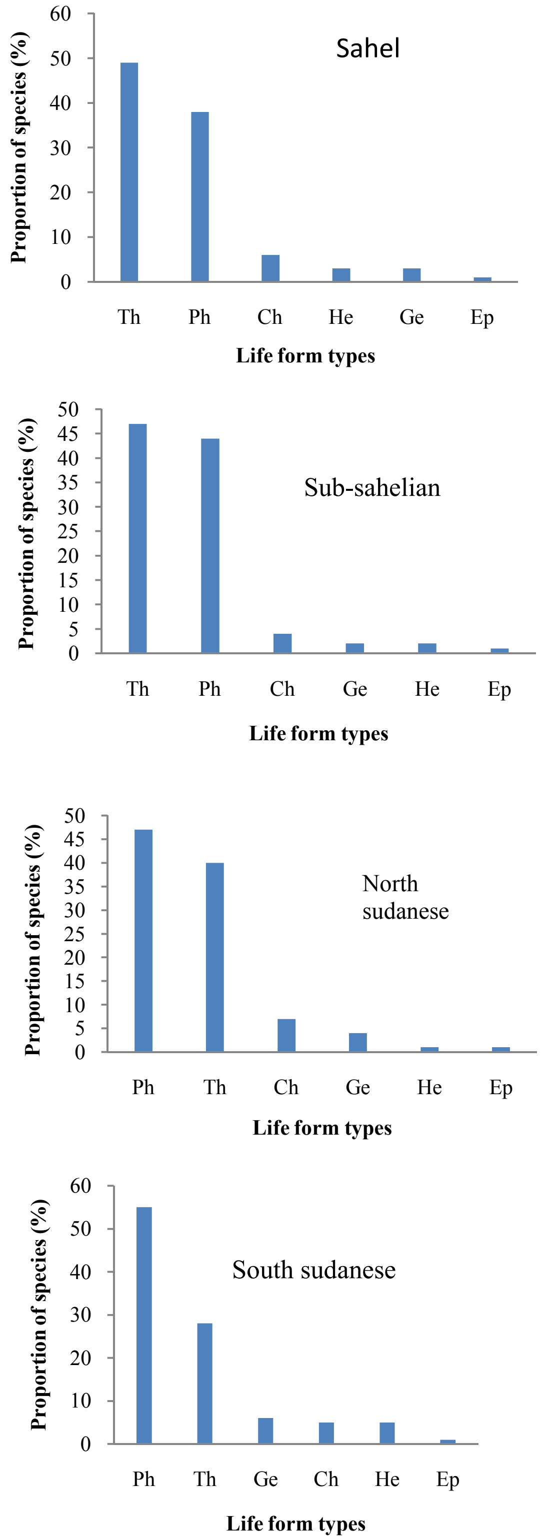


**Figure 4** Raw spectrum of life form types of the flora in the 4 phytogeographical areas

**Ph :** phanerophytes;**Th :** therophytes;**Ge :** geophytes; **Ch:** chamephytes; **Hé:** hemicryptophytes ; **Ep :** epiphytes

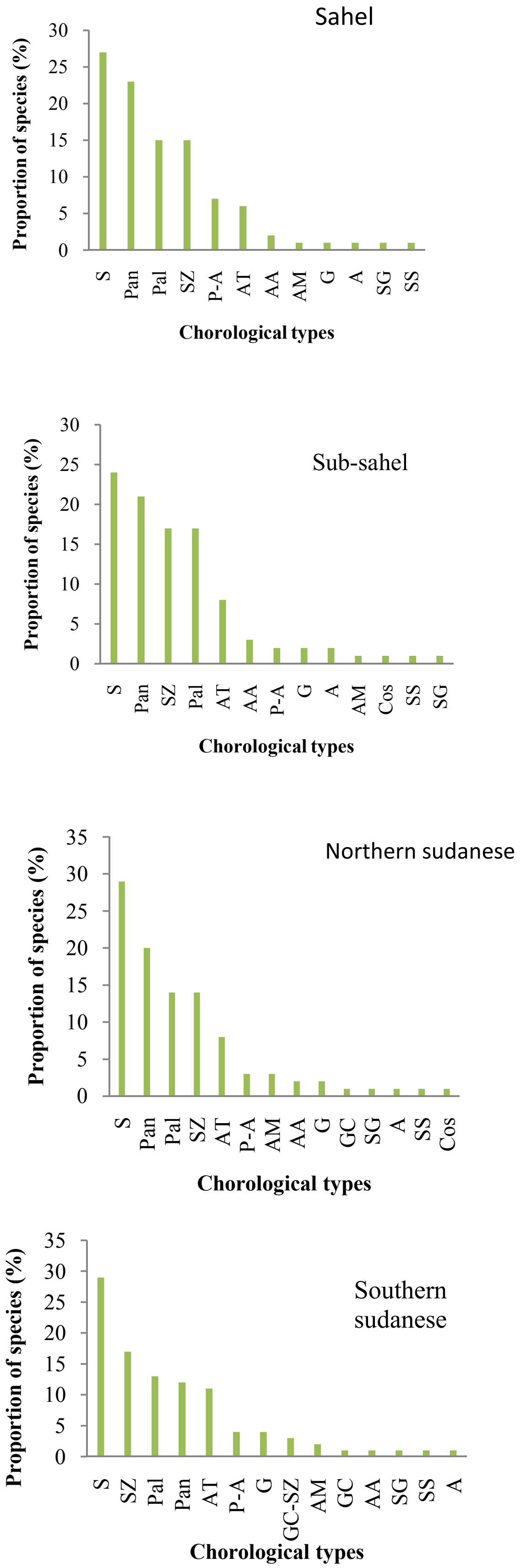


**Figure 5** Raw spectrum of chorological types of flora in 4 phytogeographical areas

(**S**: Sudanese species; **SZ**: Sudan-Zambezian species; **Pan**: Pantropical species;**Pal**: Paleotropical species; **AT**: Afro-tropical species; **PA**: other African pluri-regional species;**AM**: Afro-Malagasy species; **GC**: Guinea-Congolese Species;**SG**: Sudano-Guinean Species.**A**: African Species.**AA**: Afro-American Species.**G**: Guinean Species;**GC-SZ**: Guineo-Congolese and Sudanese-Zambezian Species).

The dominant species in the 4 phytogeography sectors are Sudanese species, Sudano-Zambezian species, Pantropical species and Paleotrpical species (Fig 5). Sudanese species, although not specific to the Sahelian zone, are abundant in the Sahelian sector.

## DISCUSION

### *Floristic richness*

The 478 species recorded in the sacred woodlands account for 24.54% of the national flora (Schmidt *et al*., 2007). That shows a relative richness of these areas despite their often reduced areas and certain unfavorable site conditions. The floristic richness grows from Sahelian sectors towards the Sudanese sectors with floristic falls ranging from 37 to 255 species for the sacred woodlands and 24 to 206 species for the adjacent savannahs. This highlights the predominance of climate, including rainfall, in the influence of the distribution of taxa. These floristic differences are more perceptible than those obtained by Ouédraogo (2006) in the eastern part of Burkina Faso. This author had shown floristic differences ranging from 57 to 104 species. This is explained by the fact that the author did not take into account the herbaceous layer. The almost constant presence of Rubiaceae and the increase of their proportion in southern Sudaneser eflect a trend towards dominating forest ecological conditions. According to Aubreville (1950), tree and shrubby Rubiaceae are rather dense forest species. These results are also in line with those of Ouédraogo (2006). This author has shown an emergence of Rubiaceae in the southern Sudanese sector of eastern Burkina Faso. The dominance of Combretaceae and Fabaceae-Mimosoideae in the sacred woodlands reveals a generally dry climate (Aubreville, 1950). This dominance was highlighted by Savadogo (2008) and Savadogogo *et al*. (2010) in northern Burkina Faso. The floristic data allow bringing out the conservative and refuge role of sacred woodlands. Species such as *Stereospermum kunthianum* reported as very rare species in eastern plant communities (Belem, 1992; Hahn-Hadjali and Thiombiano, 2000). *Boswellia dalzielii, Boscia salicifolia* and *Celtis toka* have been found in some sacred sites. These sites would play the role of conservation for very common species and refuges especially for *Stereospermum kunthianum*, *Boswelia dalzielii* and *Boscia angustifolia* for their multiple uses in pharmacopoeia. This assessment is also valid for species highly threatened with extinction or already extinct in the terroirs. The refuge of some rare species in the sacred woodlands of Burkina Faso northern region also shows their importance in the conservation of species. The strange case is especially the presence of *Manilkara multinervis* in the sacred woodland of Dierko / Yatenga. This species, never reported throughout the northern region was found for the first time in a natural settlement along a valley in Yatenga Province. According to Arbonier (2000), this species is specific to forest galleries, ravines and rocky hills in the Sudano-Guinean and Guinean savanna zones. The valley could justify the presence of this settlement in the sacred woodland. The importance of sacred sites in the conservation of ecosystems and biological diversity has been extensively addressed by natural resource managers.

*Boswelia dalzielii* was only observed in 2 sacred woodlands: some individuals in the Poufo woodland of Kiétego, province of Passoré and in the form of a settlement in the sacred woodland Zomb-noogo, province of Sanmatenga. *Cissus quadrangularis* was only harvested in the Malou community woodland in Sanmatenga province. These species, such as *Boscia senegalensis, Boscia angustifolia, Boscia salicifolia, Celtis toka, Stereospermum kunthianum, Ficus abutilifolia and Hyphaene thebaica*, have been found in several sacred groves of the strict Sahelian, sub-Sahelian and northern Sudanese areas.

In the southern Sudanese zone, *Elaeis guineensis, Entada abyssinica, Eriosema molle, Agave sisalana, Lepidagathis anobrya, Psychotria psychotrioides, Zanthoxylum zanthoxyloides* were only found in sacred woodlands.

Wangari (1996), Sokpon *et al*. (1998), Tchouamo (1998), Kokou and Sokpon (2006) and Kokou and Kokutse (2007), based on the quality and specific richness of these sites, confirmed that sacred sites are real sanctuaries of biodiversity. This sacred woodlands status is due to the protection they enjoy. In fact, certain categories of sacred woodlands, in this case haunted sacred woodlands, are perceived as the imaginary of indigenous peoples of Burkina Faso as fragments of vegetation embodying invisible creatures (Leblic, 1998; Savadogo, 2008; Savadogo *et al*., 2011), most often irritating. This belief in the invisible world, which could dangerously compromise the lives of humans, could therefore limit human interventions and preserve plant species from all forms of destruction (cutting, mutilation, trampling and pulling by animals). Malan (2009) did not say this: "Even if conservation is not the primary objective of the sacredness of a site, the presence of a Boson, feared by the community confers effective protection of natural resources of the sacred place ". On the other hand, Garcia *et al*. (2006), Juhé-Beaulaton & Roussel (2002), argue that the sacredness of these spaces does not prejudge their heritage or environmental values. It is not the elements of nature as such that are the object of worship, but the invisible creatures that inhabit them (Duchesne, 2002). The nature of sacred spaces does not always reflect the local biodiversity, which is why Juhé-Beaulaton and Roussel (2002) consider that caution should be exercised when policies aiming to include these "informal reserves" in conservation of biodiversity.

### *Life form and chorological types of species*

The strong dominance of therophytes on other life form types reflects the predominance of herbaceous plants in the two sectors of the Sahelian domain. This attests their adaptation to the arid climate. The low proportion of geophytes confirms the arid climate regime in these areas. Geophytes reach their full development on moist soils (Mbayngone, 2008). In the northern and southern parts of Sudan however, the flora is dominated by phanerophytes.

The preponderance of phanerophytes in the plant communities reflects not only edaphic conditions more favorable to forest or wooded savannahs, but also the high proportion of woody species due to reforestation of certain sacred sites and grazing pressure. The protection of sacred woodlands creates conditions (micro-climate) favorable to the development of ligneous trees. The work of Wala (2004) has shown that the distribution of biological forms reflects the ecological conditions of site. For Ouoba (2006), this predominance of phanerophytes is characteristic of areas with a humid tropical climate. It marks the forest character of the vegetation concerned. However, Mbayngone (2008) considers that the high proportion of phanerophytes in several plant communities, as is the case in the communities described in this study, rather determines a high species richness of the woody flora and not the woody character of the community. These results confirm the assertion from Schmidt *et al*. (2005) that biological types reflect not only structural parameters in vegetation but also varied environmental conditions.

The presence of hemicryptophytes, despite their small proportion, reveals soil stability in these areas and relatively good moisture conditions. The abundance of herbaceous plants, especially Poaceae and Fabaceae-Faboideae, explains the relative importance of species with wide distribution.

Chorologically, Sudanese species abound in most plant communities, showing a large ecological range of Sudanese species. The high proportions of Sudanese and Sudano-Zambezian species in some groups indicate the stability of the environments in which these communities have been described, which gives them the advantage of conserving the original biodiversity. This finding is similar to that of Béchir (2004), who believes that the high rate of Sudano-Zambezian species reveals a floristic affinity of studied plant communities with the Sudano-Guinean forests. These results are also in agreement with those of (Guinko, 1984), (Houinato, 2001) and (Adomou, 2005). According to these authors, the relatively low proportion of the Sudan-base element combined with that of the Sudano-Zambezian species reflects the fact that the study area belongs to the Sudanese domain. The abundance of widely distributed (pantropical and palaeotropic) and continental (afro-tropical) species after Sudanese species indicates that the study area belongs to the disturbed Sudanese domain (Sinsin, 2001).

## CONCLUSION

Sacred woodlands contain a very appreciable diversity of species (470) despite their often limited surface and the difficult edaphic conditions unfit for the development of species. Their floristic wealth is partly due to the customary protection and to a lesser extent to the complete self-protection enjoyed by certain sacred sites. The most dominant families are *Poaceae, Fabaceae-Mimosoideae, Fabaceae-Faboideae and Fabaceae-Ceasalpinioideae*. The sacred woodlands are dominated by phanerophytes and therophytes. Chorologically, there is a predominance of Sudanese species followed by pantropical species and Sudano-Zambezian species. Some extinct species in the terroirs normally develop in the sacred woodlands. These results show that sacred woodlands are sanctuaries of biodiversity and refuges for certain species; hence the need to preserve them in order to guarantee the survival of certain fragile species and ecosystems, which are essential for maintaining the ecological balance. Integrated management actions will help to conserve the species that are confined to them.

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