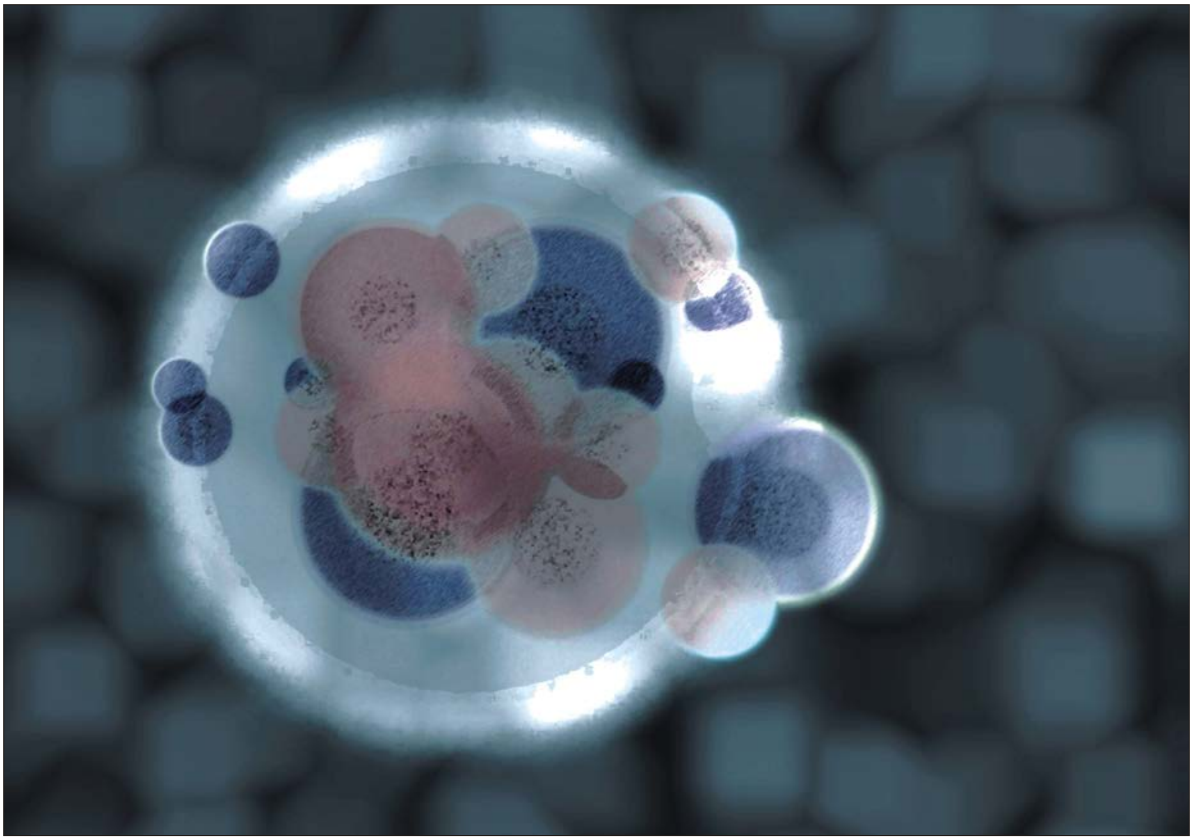

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 11 (2): 111-123, 2011
ISSN 1727-3048 / DOI: 10.3923/jbs.2011.111.123

Woody Plant Diversity and Stand Structure in the Comoe-Leraba Reserve, Southwestern Burkina Faso (West Africa)

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Abstract: The Comoe-Leraba reserve has been poorly managed or is under threat through increasing human populations settled along their boundaries. These behaviours towards the protected area lead to depletion of it resources. The objective of this study was to assess the vegetation structure in this protected area which reflected the features described above until 1997, when the management of the forest was conceded for an integrated management. A balanced completely randomized design was established in the ten plant communities of the reserve. The plots were 50×20 m^2 in size expect for termite mound vegetation, $S = \pi R^2$ corresponding to surface of the plot for termite mounds limited in the radius (R) of termite mound and 10×50 m^2, for the string-course of rivers. All woody individuals were recorded in each plot with their dbh and height. High species richness was recorded in the communities (46% of native woody species found in Burkina Faso and 64% of native woody species found in the Southwest of the country) with high beta diversity. The structure of woody species communities had a good trend. However, this forest still needs special environmental management support because many species occur at very low densities. So, the integrated management could help to protect them against extinction.

Key words: Biodiversity, community, conservation, ecosystems, management, protected area

INTRODUCTION

Several decades ago, it was realised that the planet is going into the opening phase of a mass extinction of species and since then, many studies have been made on this issue. Governments, international agencies, or NGOs have mobilised unprecedented efforts to stem the crisis (Myers, 2003). Tropical forests are the central to the issues because they share two unique characteristics. First, they are exceptionally rich in species; second, they are being destroyed faster than any other extensive biome (Osborne, 2000; Myers, 2003). Biodiversity conservation is being tackled on a number of fronts. The first of these is a species by species approach. International agreements have been signed which limit harvest and trade of species that are in danger of extinction (IUCN, 2004). Another approach is directed more towards habitat conservation with the aim of conserving the whole suite of species that inhabit an area. The global network of protected areas larger than 1000 km^{-2} grew from none in 1900 to nearly 10 000 at the end of the century, with some 3% of the earth's surface protected (Osborne, 2000). In Africa, colonial governments established many protected areas with little or no consultation with the local inhabitants. Only few protected areas have been designed and established on the basis of sound ecological concepts which relate to the species or habitats that are to be protected. However, many of these protected areas have permited to conserve biodiversity and particularly plant diversity in maintaining natural forest composition and structure (Ouoba, 2006; Ouedraogo *et al*., 2008; Mbayngone *et al*., 2008). However, concern strict forest conservation, it confronts generally on anthropogenic activities that lead to depletion forest resources (Banda *et al*., 2006). Shifting agriculture, over exploitation through selective harvest, seasonally set forest fires and woodland over grazing of cattle are the major mechanisms of forest degradation, habitat change and biodiversity loss (Thapa and Chapman, 2010). Disturbances created by these activities influence forest dynamics and tree density at local and regional scales (Ouedraogo *et al*., 2006) and are important

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in structuring plant communities. These disturbances are observed particularly evident in changing size class distributions and most after species (Lykke and Sambou, 1998). In face of such problems, conservation biologists have attempted to protect forests using several different strategies from strict to sustainable forest management and other integrated conservation and development programs (Ervin, 2003; McNeely, 2004). Many types of protected areas have been created for that purpose in Burkina Faso, with different status (National parks, classified forests, total reserves, partial reserves, zovics, cynegetic areas) in relation to the management. The protected areas have around 2,272,857 ha (FAO, 1999) representing 14% of the territory of Burkina Faso.

The classified forest and fauna partial reserve of Comoe-Leraba is the biggest classified forest representing 11.23% of the classified forests and the second biggest fauna partial reserve representing 22.32%, of the fauna partial reserves of the country (FAO, 1999). This protected area was established by regrouping two existing classified forests (Diefoula and Logoniegue classified respectively in 1937 and 1955). These two forests have been poorly managed and are under threat from increasing human populations settled along their boundaries (Guinko, 1997). There was a lack of financial support and adequately trained personnel to manage them and therefore they had little more than legal status. Since 1997 the two classified forests were conceded to an association « Comoe-Leraba classified Forest and Fauna partial Reserve's inter-villages Association of natural resources Management (FREM) » for integrated management based on local participation.

Few studies have dealt with this reserve's vegetation. The vegetation has been mapped with aerial photographs for management purposes (Guinko, 1997). However, this method does not provide detailed analysis of forest stands structure, composition and species diversity that can only be obtained at a local scale of investigation.

Regarding conservation and sustainable use of the resources in this reserve it is important to have detailed knowledge about the vegetation structure and species composition in different ecosystems. Studies of spatial variation in community composition have provided key insights into how factors, such as environmental variables, disturbance history and dispersal influence local biodiversity (McCune and Grace, 2002; Cottenie, 2005). In addition, sustainable resource management of a specific forest requires that its biodiversity (species composition and stand structure) and ecological processes be known and maintained to ensure sustained resources used (Geldenhuys, 2009).

The main objective of this study is to assess the woody species layer structure in the Comoe-Leraba reserve after 13 years of management by FREM (Comoe-Leraba classified Forest and Fauna partial Reserve's inter-villages Association of natural resources Management). The specific objectives are: (1) to assess the taxonomic diversity of the woody layer; (2) to assess the woody species community's diversity and similarity and (3) to assess the stand structure of the population of different plant communities.

MATERIALS AND METHODS

Study area: The study site is located in the phytogeographical district of Comoe of Burkina Faso's South Sudanian sector. It comprises the protected forest of Comoe-Leraba (4°53'N, 9°50'W) stated in 1997 with a size of 125,000 ha (Fig. 1). The area has a tropical climate with two very distinct seasons: An unimodal rainy season and a dry season (Guinko, 1984). The mean annual precipitation at the nearest climatic station (Banfora) is 1100 mm and the mean number of rainy days per year is 90 days. The rainy season lasts approximately 10 months, from March to November. The vegetation consists mainly of dry forests, with patches of rain forests and is characterised by Sudanian and Guinean species. The most frequently encountered soils are ferric ferralsols. The local association FREM that controls the harvesting of non-timber forest products and the setting of early fires manages the forest. The surrounding populations practice agriculture, husbandry and forestry. The fieldwork was conducted in this area during the rainy seasons of 2008 and 2009.

Studied communities: The vegetation is composed of ten plant communities (Table 1) (Gnoumou, unpublished data). The communities of *Monotes kertinjii* (Mon-ker), Isoberlinia doka (Iso-dok), *Detarium microcarpum* (Det-mic), *Anogeissus leiocarpa* (Ano-lei), *Mitragyna inermis* (Mit-ine), *Terminalia macroptera* (Ter-mac), *Berlinia grandiflora* (Ber-gra), *Guibourtia copallifera* (Gui-cop), *Syzygium guineense*(Syz-gui) and *Tamarindus indica* (Tam-ind).

Experimental design: During the rainy seasons of 2008 and 2009 we selected plots according to a stratified random sampling based on the knowledge of existing plant communities. We established a balanced completely randomized design. The survey concerned only the ligneous stratum and the plots size varied according to the type of vegetation:

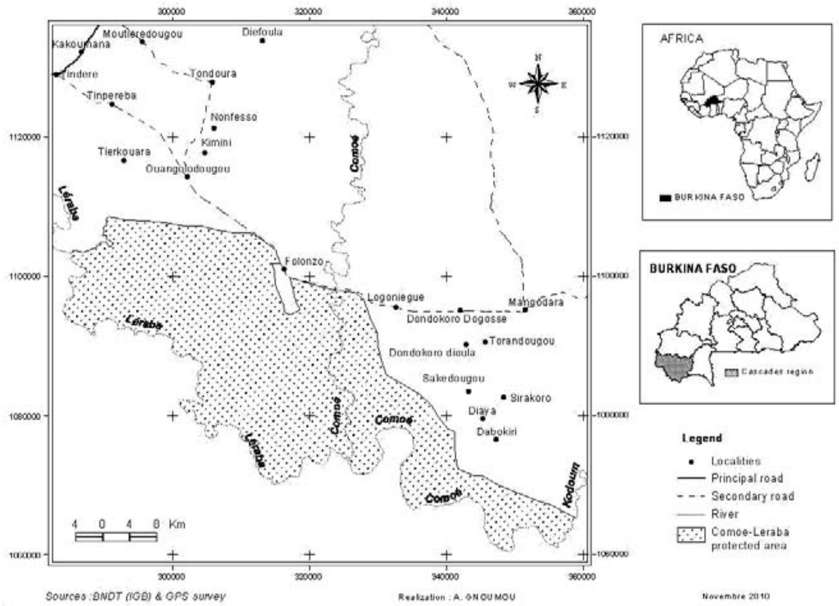

Fig. 1: Location of the study site

Table 1: Characteristics of woody communities

Woody communities	Two main Characteristic of species	Soil type	Vegetation type	Topography
Anogeissus leiocarpa (Ano-lei)	*Anogeissus leiocarpa, Cassia sieberiana*	Ferric cambisol, leptic cambisol,	Forest	middle glacis
Berlinia grandiflora (Ber-gra)	*Berlinia grandifolia, Paullinia pinnata*	Cambisol endogleyic	Woodland savannah	String-course river
Detarium microcarpum (Det-mic)	*Detarium microcarpum, Pteleopsis suberosa*	Ferrasol ferric, Ferrasol Plinthic	Woodland savannah	middle glacis
Guibourtia copallifera (Gui-cop)	*Guibourtia copallifera, Gardenia nitida*	Cambisol	Forest	Lower glacis
Isoberlinia doka (Iso-dok)	*Isoberlinia doka, Isoberlinia tomentosa*	Leptosol	Forest and woodland savaunah	High glacis
Mitragyna inermis (Mit-ine)	*Mitragyna inermis, Tacazzea apiculata*	Gleysol	Woodland savannah	Floodplain
Monotes kertinjii (Mon-ker)	*Monotes kerstingii, Burkea africaua*	Pisoplinthic, Leptosols	Woodland savannah	High glacis
Syzygium guineeuse (Syz-gui)	*Syzygium guineense, Manilkara obovata*	Gleysol	Gallery forest	River bed
Terminalia macroptera (Ter-mac)	*Terminalia macroptera , Pseudocedrela kotschyi*	Lixisol gleyic	Woodland savannah	Floodplain
Tamarindus indica (Tam-ind)	*Tamarindus indica, Diospyros mespiliformis*	All types of soils except the gleysol	Clump of trees	Termites' mound

- All plant communities (except termite mounds and string courses of rivers): 1000 m^2 (50×20 m^2)
- For termite mounds (in Tam-ind) limited in the radius (R) of termite mound corresponding plot area is $S = \pi R^2$
- For the string-course of rivers (in Ber-gra), 500 m^2 (10×50 m^2)
- A total of 145 plots was chosen in representative areas for data collection. The number of plots per community was: 8 Mon-ker; 10 Ber-gra; 10 Ter-mac; 10 Sys-gui; 11 Mit-ine; 11 Gui-cop; 15 Iso-ber; 16 Ano-lei; 20 Tam-ind and 34 Det-mic

Vegetation recording: Each sample plot was systematically surveyed and species were recorded and identified. Nomenclature follows Lebrun and Stork (1997), Arbonnier (2002) and Hawthorne and Jongkind (2006). We quantified the abundance of plants species, the diameter at breast (DBH) of each adult individual and the height of each individual.

Calculations: To analyse the relationship between environmental factors and plant communities, we calculate diversity and dissimilarity indices. We calculated Shannon's diversity index (H) and Pielou index (J) (McCune and Grace, 2002).

The Jaccard and Sørensen's similarity indices were calculated to measure the β diversity (McCune and Grace, 2002) of pairs of plant communities. They were calculated based on presence/absence of species.

The relative ecological importance of each woody species in the plots of each plant community was expressed using the Importance Value Index (IVI) (Heikkinen and Birks, 1996).

Structural characteristics (density, diameter class distributions) were computed for each plot and averaged per plant community for all individuals. The plants were grouped into 13 diameter classes of 5 cm interval (5 cm ≤ diameter ≤ 60 cm). Several methods are used to describe the stand structure of trees. Weibull distribution was used in this study because it is a model that has been widely used in the description of some forests (Ryniker *et al*., 2006) and seems to be the best suited (Merganic and Sterba, 2006).

Thus, Weibull function was used to model the stand structure (diameter classes) of the plant communities.

The skewness parameter (g) of function was calculated:

- **For g<0:** Left skew, meaning that the plant communities are aging with a high number of individuals with large diameter
- **For g>0:** Right skew, which reflects a high number of individuals of small diameter
- **For g = 0:** Perfect symmetry, which reflects the dominance of the middle classes, a sign of the communities' degradation

Statistical analysis: We run analysis of variances to compare species richness, diversity indices and plant density between plant communities. We also used a pair wise test of Tukeys-Kramer HSD (Schlotzhauer, 2007). We used Tukeys-Kramer HSD because the samples were unbalanced. All the statistical analyses and diversity calculation were performed with JMP.7 and Excel softwares.

RESULTS

Taxonomic diversity and plant communities' composition: A total of 128 species representing 95 genera and 39 families were recorded in the protected forest of Comoe-Leraba. Species richness varied significantly among some plant communities (Fig. 2, d. f = 9, F= 18.5, p = 0.0001). The richest plant communities were Syz-gui and Ber-gra communities with 12.50±0.95 species. Mit-ine community had the lowest species richness (1.27±0.91).

The importance of species varies among plant communities (Table 2). The species with the highest importance value were *A. leiocarpa* in the Ano-lei community (IVI = 91.87), *B. grandiflora* in the Ber-gra community (IVI = 59), *M. kerstinjii* in the Mon-ker community (IVI =144.26), *G. copallifera* in the Gui-cop community (IVI = 198.67), *I. doka* in the Iso-dok community (IVI= 108.09), *T. macroptera* in the Ter-mac community (IVI = 190.60), *M. inermis* in the Mit-ine community (IVI= 299.10), *S. guineense* in the Syz-gui community (IVI= 57.26), *D. microcarpum* in the Det-mic community (IVI= 53.35) and *D. mespiliformis* in the Tam-ind community (IVI= 40.90). Each species with highest IVI in a community, corresponded to one of the indicator species of this woody plant community identified by phytosociological approach.

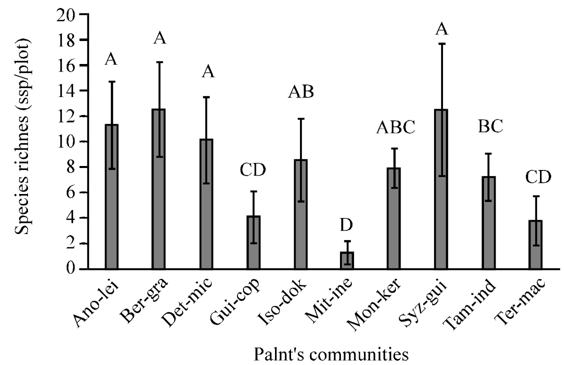

Fig. 2: Distribution of mean species of woody vegetation in the ten communities of Comoé-Léraba protected area The histograms connected with the same letter present a non-significative difference of means between woody communities, while those not connected with the same letters show significative differences

The family of Ceasalpiniaceae was the most abundant family in Ber-gra, Gui-cop, Iso-dok and Det-mic plant communities (Table 3). The most important family, in Ano-lei and Ter-mac communities was the Combretaceae family. Rubiaceae, Myrtaceae, Dipterocarpaceae and Ebenaceae families were most abundant, respectively in Mit-ine, Syz-gui, Mon-ker and Tam-ind plant communities. In the whole reserve the families Rubiaceae, Ceasalpiniaceae and Combretaceae were the most important.

Plant communities' diversity: To allow a precise comparison of alpha diversity among plant communities, a variety of diversity measures was computed (Table 4). The analysis revealed that the species diversity varied significantly among plant communities accordingly to Shannon's index (d.f = 9; F = 42.51; p=0.0001) and Pieulou's evenness (d.f.= 9; F = 26.32; p=0.0001). But the communities of Ano-lei, Gui-cop and Sys-gui are the same value Pieulou's evenness. Ber-gra community was the most diverse plant community (H = 0.52) and Mit-ine the least diverse community (H = 0.10). Ter-mac community has the highest evenness (J = 0.18) and Mit-ine the lowest evenness (J = 0.01).

Table 2: Summary of the importance value of index for the species in the ten communities in Comoé-Léraba rotected area

Species	Whole reserve	Ano-lei	Ber-gra	Mon-ker	Gui-cop	Iso-dok	Ter-mac	Mit-ine	Syz-gui	Det-mic	Tam-ind
Acacia dudgeoni	0.98	-	-	-	-	1.02	-	-	-	3.92	-
Acacia polyacantha	0.15	0.65	-	-	-	-	-	-	-	-	-
Acacia sieberiana	1.40	9.61	-	-	-	-	-	-	-	-	1.73
Afzelia africana	1.06	-	2.75	6.19	-	5.26	-	-	-	1.90	-
Alafia scadens	2.13	-	-	-	2.14	-	-	-	-	-	-
Annona senegalensis	0.30	-	-	-	-	-	-	-	-	1.11	-
Anogeisus leiocarpa	12.54	91.87	10.77	-	2.15	1.01	-	-	-	0.51	10.47
Antidesma venosum	0.65	-	7.56	-	-	-	-	-	-	-	-
Berlinia grandifolia	7.07	-	59.00	-	-	-	-	-	7.58	-	-
Bombax costatum	0.45	-	-	2.33	-	-	-	-	-	0.54	2.33
Bridelia ferruginea	0.83	0.62	-	2.25	-	0.97	-	-	-	2.54	-
Bridelia micrantha	5.67	-	2.59	-	-	0.95	-	-	-	-	22.70
Bridelia scleroneura	0.31	-	-	-	-	-	-	-	-	1.29	-
Burkea africana	2.35	-	-	23.56	-	-	-	-	-	7.95	-
Capparis corymbosa	0.11	0.68	-	-	-	-	-	-	-	-	-
Carissa edulis	0.19	-	1.03	-	-	-	-	-	-	-	1.02
Cassia sieberiana	1.79	10.99	1.03	-	2.15	-	-	-	-	-	-
Cassipourea congoeusis	2.78	2.17	-	-	2.21	-	-	-	24.41	-	-
Cola cordifolia	2.61	25.77	3.33	-	-	-	-	-	-	-	-
Cola laurifolia	3.48	-	-	-	-	-	-	-	39.89	-	-
Combretum collinnm	0.13	-	-	-	-	1.37	-	-	-	-	-
Combretum adenogonium	9.06	9.07	-	13.86	-	12.26	15.75	-	-	13.22	17.15
Combretum molle	2.14	3.16	-	6.50	-	5.37	3.02	-	-	1.52	2.05
Combretum nigricans	0.09	0.62	-	-	-	-	-	-	-	-	-
Combretum paniculatum	0.19	0.61	-	-	-	-	-	-	1.07	-	-
Combretum tarqneuse	0.11	-	-	-	2.26	-	-	-	-	-	-
Cordia myxa	0.13	0.83	-	-	-	-	-	-	-	-	-
Crataeva adansonii	6.99	6.46	-	-	2.15	-	-	-	-	-	28.02
Crossopteryx febrifuga	1.55	1.22	-	2.11	-	1.37	3.04	-	-	6.84	-
Crytolepis sanguinolenta	0.12	-	-	-	2.52	-	-	-	-	-	-
Cussonia arborea	0.33	-	1.37	-	-	-	-	-	-	-	2.10
Dalbergia hostilis	0.19	-	-	-	4.29	-	-	-	-	-	-
Daniellia oliveri	2.18	-	4.53	4.29	-	3.07	-	-	-	6.70	-
Detarium microparpum	10.33	2.27	4.95	17.68	-	5.75	-	-	-	53.35	1.34
Dialium guineense	3.55	-	-	-	2.27	-	-	-	37.99	-	-
Dichrostachys cinerea	0.95	4.92	1.03	-	-	-	-	-	-	-	1.02
Diospyros heudelotii	3.17	10.15	-	-	26.17	-	-	-	-	-	-
Diospyros mespiliformis	11.80	32.58	37.29	-	16.79	-	-	-	4.65	-	40.90
Dissomeria crenata	0.81	-	-	-	-	-	-	-	8.62	-	-
Drypetes floribunda	0.85	0.61	-	-	7.77	-	-	-	3.12	-	-
Elaeis guineensis	0.15	-	1.38	-	-	-	-	-	-	-	-
Entada abyssinica	0.34	-	-	2.12	-	1.46	-	-	-	0.46	-
Entada africana	0.09	-	-	-	-	-	-	-	-	0.34	-
Entada walberjii	0.09	-	-	-	-	-	-	-	1.04	-	-
Erythrophleum africanum	0.11	-	-	-	-	-	-	-	-	0.90	-
Zanthoxylum zanthoxyloides	0.59	-	-	-	-	-	-	-	-	-	4.81
Feretia apodanthera	0.33	1.46	-	-	-	-	-	-	-	-	1.04
Ficus ingens	0.43	-	-	-	-	-	-	-	-	1.04	1.86
Ficus platyphylla	0.19	-	-	-	-	0.95	-	-	-	-	1.03
Ficus lecardii	0.19	0.61	-	-	-	0.99	-	-	-	-	-
Ficus sur	0.41	0.61	3.44	-	-	-	-	-	-	-	-
Ficus thonningii	0.13	-	-	-	-	-	-	-	-	-	1.17
Flabelaria panniculata	0.20	-	1.03	-	-	-	-	-	1.14	-	-
Flacourtia flavesceus	2.71	-	4.91	-	-	-	-	-	-	-	10.79
Fluggea virosa	0.10	0.69	-	-	-	-	-	-	-	-	-
Gardenia erubescens	1.82	0.70	-	-	-	1.08	6.99	-	-	5.83	-
Gardenia aqualla	0.74	-	-	-	-	-	-	-	-	3.26	-
Gardenia ternifolia	0.09	-	-	-	-	-	2.99	-	-	-	-
Guibourtia copallifera	17.41	-	-	-	198.67	-	-	-	-	-	-
Hymenocardia acida	0.71	-	-	-	-	-	-	-	-	4.14	-
Hymenocardia heudelotii	1.74	-	-	-	-	-	-	0.31	16.80	-	-
Isoberlinia doka	5.40	-	2.00	-	-	108.09	3.72	-	-	2.35	1.42
Isoberlinia tomentosa	3.59	-	-	-	-	26.80	-	-	-	0.36	-
Keetia venosum	0.12	-	1.38	-	-	-	-	-	-	-	-
Khaya senegaleusis	2.41	-	19.23	-	-	-	-	-	-	-	4.35
Kigelia africana	0.84	6.10	-	-	-	-	-	-	-	-	-
Landolphia hisurta	0.58	-	-	-	10.37	-	-	-	-	-	-

Table 2: Continued

Species	Whole reserve	Ano-lei	Ber-gra	Mon-ker	Gui-cop	Iso-dok	Ter-mac	Mit-ine	Syz-gui	Det-mic	Tam-ind
Lannea acida	5.38	5.82	2.41	2.37	-	7.95	-	-	-	7.73	15.19
Lannea kerstingii	1.42	3.53	4.22	-	-	-	3.09	-	-	0.40	3.25
Lannea velutina	0.09	-	-	-	-	-	-	-	-	0.38	-
Lonchocarpus laxiflorius	0.19	-	1.04	2.00	-	-	-	-	-	-	-
Lonchoncarpus cyanescens	1.08	3.99	-	-	-	-	-	-	2.43	-	3.10
Lophira lanceolata	0.20	-	-	-	-	-	-	-	-	1.59	-
Maerua angolensis	0.49	-	-	-	-	-	-	-	-	-	2.62
Malacantha alnifolia	0.42	-	-	-	-	-	-	-	-	-	3.86
Mallotus oppositifolius	0.55	0.63	-	-	2.64	-	-	-	3.26	-	-
Manilkara multinervis	0.31	-	-	-	-	-	-	-	3.42	-	-
Manilkara obovata	1.96	-	-	-	-	-	-	-	22.18	-	-
Maranthes polyandra	2.45	-	-	-	-	-	-	-	-	15.65	-
Maytenus senegalensis	2.69	0.61	-	3.65	-	9.26	-	-	-	5.99	1.24
Mumusops kummel	6.01	9.10	25.58	-	-	-	-	0.26	-	-	22.07
Mitragyna inermis	45.26	-	8.05	-	-	-	-	299.10	4.39	-	-
Monotes kertingii	8.25	-	-	144.26	-	28.95	-	-	-	1.00	-
Morelia senegalensis	1.42	-	1.04	-	-	-	-	-	14.11	-	-
Myrianthus serratus	0.28	-	-	-	-	-	-	-	3.35	-	-
Napoleonea vogelii	0.72	-	-	-	10.66	-	-	-	-	-	-
Onchoba spinosa	1.00	6.58	-	-	-	-	-	-	-	-	-
Opilia celtidifolia	0.61	-	1.04	-	-	-	-	-	-	-	5.21
Oxyantns racemosns	0.26	-	-	-	-	-	-	-	2.91	-	-
Parinari congensis	0.40	-	-	-	-	-	-	-	4.75	-	-
Parinari curatellifolia	2.02	-	-	-	-	-	-	-	-	11.22	-
Parkia biglobosa	0.09	-	-	-	-	0.95	-	-	-	-	-
Pavetta corymbosa	1.49	-	18.39	-	-	-	-	-	-	-	-
Pavetta crassipes	0.09	-	-	-	-	-	-	-	-	0.33	-
Pericopsis laxiflora	2.20	-	1.07	3.02	-	12.22	-	-	-	4.71	-
Piliostigma thonningii	3.84	6.81	1.06	-	-	4.15	10.62	-	-	9.33	-
Prosopis africana	0.70	-	-	2.29	-	1.34	3.10	-	-	1.41	-
Pseudocedrela kotschyi	5.37	0.71	-	2.18	-	0.94	16.87	-	-	1.23	18.64
Pteleopsis suberosa	4.26	-	-	-	-	-	-	-	-	21.46	-
Pterocarpns erinacens	2.16	1.60	2.80	4.19	-	5.67	3.92	-	-	2.38	3.24
Pterocarpns santalinoides	1.87	-	-	-	-	-	-	-	20.29	-	-
Saba senegalensis	3.64	5.99	9.74	-	-	-	-	-	1.14	-	18.52
Salacia pallescens	0.09	-	-	-	-	-	-	-	1.03	-	-
Salacia sthulmaniana	0.11	-	-	-	-	-	-	-	1.16	-	-
Sarcocephalus latifolius	0.89	0.62	4.41	-	-	-	3.03	-	1.04	0.89	-
Sterculia setigera	0.26	-	-	-	-	0.98	-	-	-	-	1.29
Stereospermum kunthianum	0.57	-	-	-	-	-	-	-	-	1.14	3.49
Strychnos innocua	0.09	-	-	-	-	-	-	-	-	0.39	-
Strychnos spinosa	0.52	3.46	-	-	-	-	-	-	-	0.53	-
Swartzia madagascariensis	0.20	-	-	-	-	-	-	-	2.29	-	-
Syzygium guineense var. macrocarpum	3.52	-	13.34	1.83	-	-	3.94	-	-	14.11	-
Syzygium guinnense var guineense	5.63	-	4.58	-	-	-	-	-	57.26	-	-
Tamarindus indica	3.49	7.33	-	-	2.64	-	-	-	-	-	28.17
Tarrena pavetoides	0.22	-	-	-	-	-	-	0.34	1.08	-	-
Terminalia glaucescens	0.44	-	3.34	-	-	-	-	-	-	0.48	-
Terminalia laxiflora	7.83	5.62	1.18	27.30	-	7.63	8.94	-	-	27.84	1.03
Terminalia macroptera	5.31	-	1.83	-	-	-	190.60	-	-	0.68	-
Terminalia mollis	4.99	-	1.25	9.75	-	6.24	-	-	-	19.46	-
Trichilia emetica	0.68	0.64	-	-	-	-	-	-	-	2.15	-
Uapaga togoensis	0.70	-	-	2.76	-	4.75	-	-	-	0.76	-
Uvaria chamae	0.45	0.86	1.04	-	2.14	-	-	-	1.45	-	-
Vernonia colorata	0.10	-	1.03	-	-	-	-	-	-	-	-
Vitellaria paradoxa	8.76	4.70	2.57	13.49	-	19.27	20.41	-	-	22.94	8.48
Vitex doniana	1.79	-	17.36	-	-	-	-	-	-	-	-
Vitex simplicifolia	0.37	-	-	-	-	0.98	-	-	-	0.98	-
Xeroderris stuhlmannii	0.49	-	-	-	-	-	-	-	-	2.11	-
Ximenia americana	1.83	1.32	1.03	-	-	10.95	-	-	-	0.69	3.28
Xylopia parviflora	0.58	-	-	-	-	-	-	-	6.13	-	-

When comparing species similarity between plant communities, similarity varied among them (Table 5). The highest value was observed between Mon-ker and Iso-dok communities and the lowest between Syz-gui, Iso-dok, Mit-ine and Mon-ker communities.

Table 3: Summary of the importance value of index for specie's families in the Comoé-Léraba protected area

Families	Whole reserve	Ano-lei	Ber-gra	Mon-ker	Gui-cop	Iso-dok	Ter-mac	Mit-ine	Syz-gui	Det-mic	Tam-ind
Anacardiaceae	4.32	6.72	7.08	5.13	-	6.18	6.70	-	-	8.85	14.06
Annonaceae	2.85	2.50	2.43	-	5.65	-	-	-	10.51	2.22	-
Apocynaceae	4.68	3.86	8.87	-	13.42	-	-	-	3.54	-	15.16
Araliaceae	0.87	-	2.76	-	-	-	-	-	-	-	3.40
Arecaceae	0.85	-	2.78	-	-	-	-	-	-	-	-
Asclepiadaceae	0.82	-	-	-	6.03	-	-	-	-	-	-
Asteraceae	0.79	-	2.42	-	-	-	-	-	-	-	-
Bignoniaceae	1.99	3.97	-	-	-	-	-	-	-	2.51	4.79
Bombacaceae	0.99	-	-	5.09	-	-	-	-	-	2.19	4.33
Boraginaceae	0.83	2.46	-	-	-	-	-	-	-	-	-
Caesalpiniaceae	55.00	19.42	76.48	48.48	199.39	140.09	16.31	-	45.71	78.92	25.75
Capparidaceae	9.18	8.80	-	-	5.66	-	-	-	-	-	33.95
Celastraceae	1.66	2.25	-	4.83	-	9.09	-	-	-	4.11	3.25
Chrysobalanaceae	5.33	-	-	-	-	-	-	-	5.28	25.28	-
Combretaceae	29.01	104.64	19.87	41.47	11.44	32.88	198.56	-	3.46	71.75	28.23
Dipterocarpaceae	7.56	-	-	135.91	-	25.58	-	-	-	2.38	-
Ebenaceae	11.69	40.09	31.65	-	23.46	-	-	-	5.18	-	31.02
Euphorbiaceae	14.39	9.09	9.02	10.53	13.36	11.76	-	25.19	10.24	13.71	24.71
Fabaceae	8.66	4.01	8.30	15.90	5.76	15.95	7.54	-	21.91	9.80	7.55
Flacourtiaceae	4.12	4.45	3.96	-	-	-	-	-	-	-	12.09
Hippocrateaceae	1.60	-	-	-	-	-	-	-	6.99	-	-
Hymenocardiaceae	1.78	-	-	-	-	-	-	-	12.66	-	-
Lecythidaceae	1.26	-	-	-	10.09	-	-	-	-	-	-
Loganiaceae	1.85	6.73	-	-	-	-	-	-	-	4.22	-
Malpighiaceae	0.82	-	2.42	-	-	-	-	-	3.54	-	-
Meliaceae	8.35	4.62	15.94	4.94	-	3.17	9.96	-	-	4.79	24.90
Mimosaceae	8.64	13.64	2.42	9.94	-	13.69	6.72	-	3.44	10.56	6.76
Moraceae	5.26	4.49	3.27	-	-	6.40	-	-	5.75	2.42	10.06
Myrtaceae	8.17	-	16.80	4.59	-	-	7.56	-	52.18	12.50	-
Ochnaceae	0.82	-	-	-	-	-	-	-	-	2.97	-
Olacaceae	1.30	2.42	2.42	-	-	7.58	-	-	-	2.07	3.89
Opilaceae	0.90	-	2.43	-	-	-	-	-	-	-	4.42
Rhizophoraceae	2.41	2.74	-	-	5.73	-	-	-	18.40	-	-
Rubiaceae	58.68	10.01	33.83	4.87	-	6.91	27.89	249.67	28.99	19.70	3.04
Rutaceae	1.13	-	-	-	-	-	-	-	-	-	5.41
Samydaceae	1.26	-	-	-	-	-	-	-	8.22	-	-
Sapotaceae	12.92	11.16	24.68	8.31	-	14.30	18.76	25.14	20.12	16.98	29.93
Sterculiaceae	7.29	25.79	4.72	-	-	3.21	-	-	33.88	-	3.29
Verbenaceae	2.74	-	13.28	-	-	3.21	-	-	-	2.09	-

Table 4: Woody species diversity in the ten communities of Comoé-Léraba protected area

Measure	Ano-lei	Ber-gra	Det-mic	Gui-cop	Iso-dok	Mit-ine	Mon-ker	Sys_gui	Ter-mac	Tam-ind
Species richness (S)	11.37±0.86	12.5±1.17	10.35±0.61	4.45±0.59	8.33±0.08	1.27±0.27	7.87±0.54	12.5±1.65	3.90±0.60	7.20±0.42
Shannon's diversity index (H)	0.38±0.02	0.50±0.00	0.42±0.01	0.19±0.02	0.41±0.01	0.10±0.01	0.39±0.02	0.35±0.01	0.36±0.03	0.47±0.01
Pieulou (J)	0.10±0.00	0.14±0.00	0.13±0.00	0.10±0.00	0.14±0.00	0.01±0.01	0.13±0.00	0.10±0.00	0.18±0.02	0.17±0.00

Table 5: Similarity in species composition between the ten plants communities of Comoé-Léraba protected area

	Ano-lei	Ber-gra	Det-mic	Gui-cop	Iso-dok	Mit-ine	Mon-ker	Syz-gui	Ter-mac
Jaccard									
Ber-gra	0.51								
Det-mic	0.48	0.43							
Gui-cop	0.30	0.08	0.01						
Iso-dok	0.53	0.40	0.87	0.02					
Mit-ine	0.02	0.05	0.00	0.00	0.00				
Mon-ker	0.31	0.32	0.44	0.00	0.57	0.00			
Syz-gui	0.19	0.19	0.03	0.20	0.00	0.00	0.00		
Ter-mac	0.39	0.27	0.65	0.00	0.69	0.00	0.75	0.02	
Tam-ind	0.53	0.79	0.45	0.09	0.56	0.03	0.33	0.05	0.65
Sorensen									
Ber-gra	0.40								
Det-mic	0.39	0.38							
Gui-cop	0.32	0.13	0.53						
Iso-dok	0.41	0.36	0.64	0.04					
Mit-ine	0.04	0.08	0.00	0.00	0.00				
Mon-ker	0.32	0.33	0.59	0.00	0.78	0.00			
Syz-gui	0.24	0.24	0.05	0.25	0.00	0.00	0.00		
Ter-mac	0.36	0.30	0.44	0.00	0.45	0.00	0.46	0.04	
Tam-ind	0.51	0.47	0.38	0.15	0.42	0.05	0.33	0.09	0.57

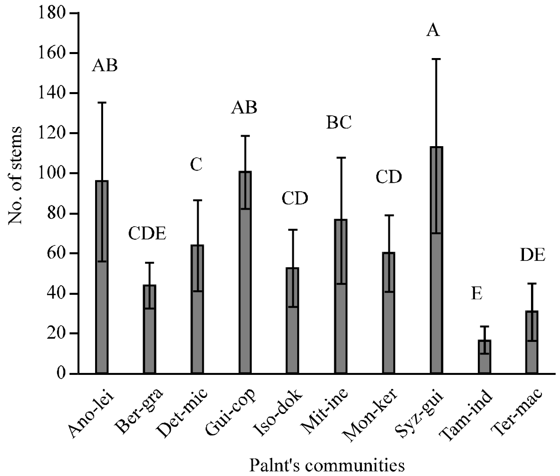

Fig. 3: Distribution of mean of stems woody vegetation in the ten communities of Comoé-Léraba protected area The histograms connected with the same letter present a non-significative difference of means between woody communities, while those not connected with the same letters show significative differences

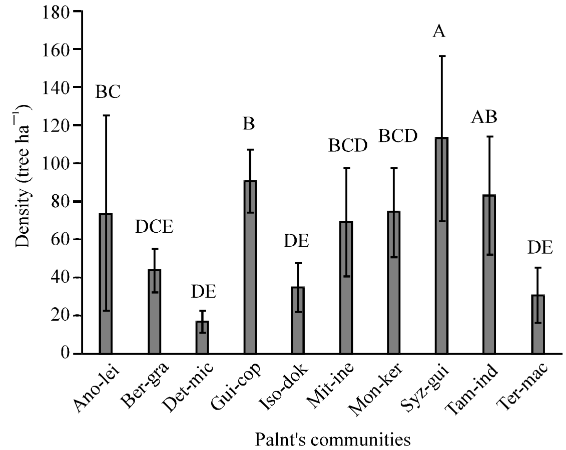

Fig. 5: Distribution of mean density of woody vegetation in the ten communities of Comoé-Léraba protected area The histograms connected with the same letter present a non-significative difference of means between woody communities, while those not connected with the same letters show significative differences

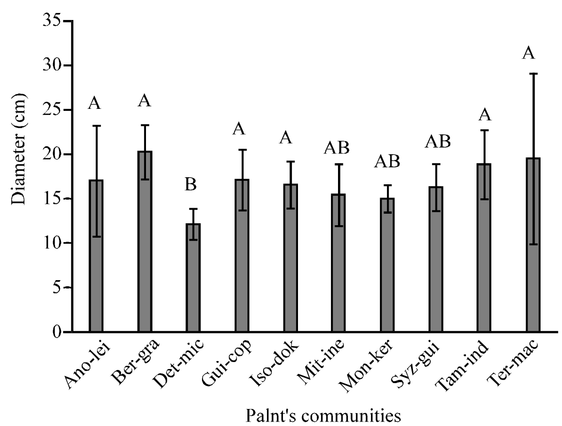

Fig. 4: Distribution of mean diameter of woody vegetation in the ten communities of Comoé-Léraba protected area The histograms connected with the same letter present a non-significative difference of means between woody communities, while those not connected with the same letters show significative differences

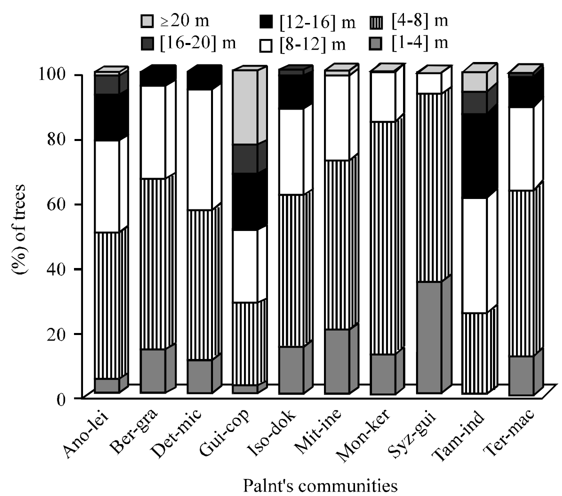

Fig. 6: Distribution of trees' height per percent in the ten communities of Comoé-Léraba protected area

Plant communities' stand structure: The stand structure of the plant communities varied significantly accordingly to the number of stems (d.f = 9; F = 21.53; $p < 0.001$), the density (d.f = 9; F= 26.52, $p<0.001$), the basal area (d.f. = 9; F = 36.79; $p<0.001$) and the mean diameter (d.f. = 9; F = 6.64; $p<0.001$). The highest number of stems was found in the Syz-gui community and the lowest one in the Tam-ind community and concerning the comparison by pair between communities showed a similarity between Ano-lei and Gui-cop also between Iso-dok and Mon-ker (Fig. 3). The largest mean diameter was found in six communities (Ber-gra; Ter-mac, Tam-ind, Gui-cop; Ano-lei; Iso-dok) and the smallest one in Det-mic community (Fig. 4). The comparison by pair between communities mean diameters showed a similarity

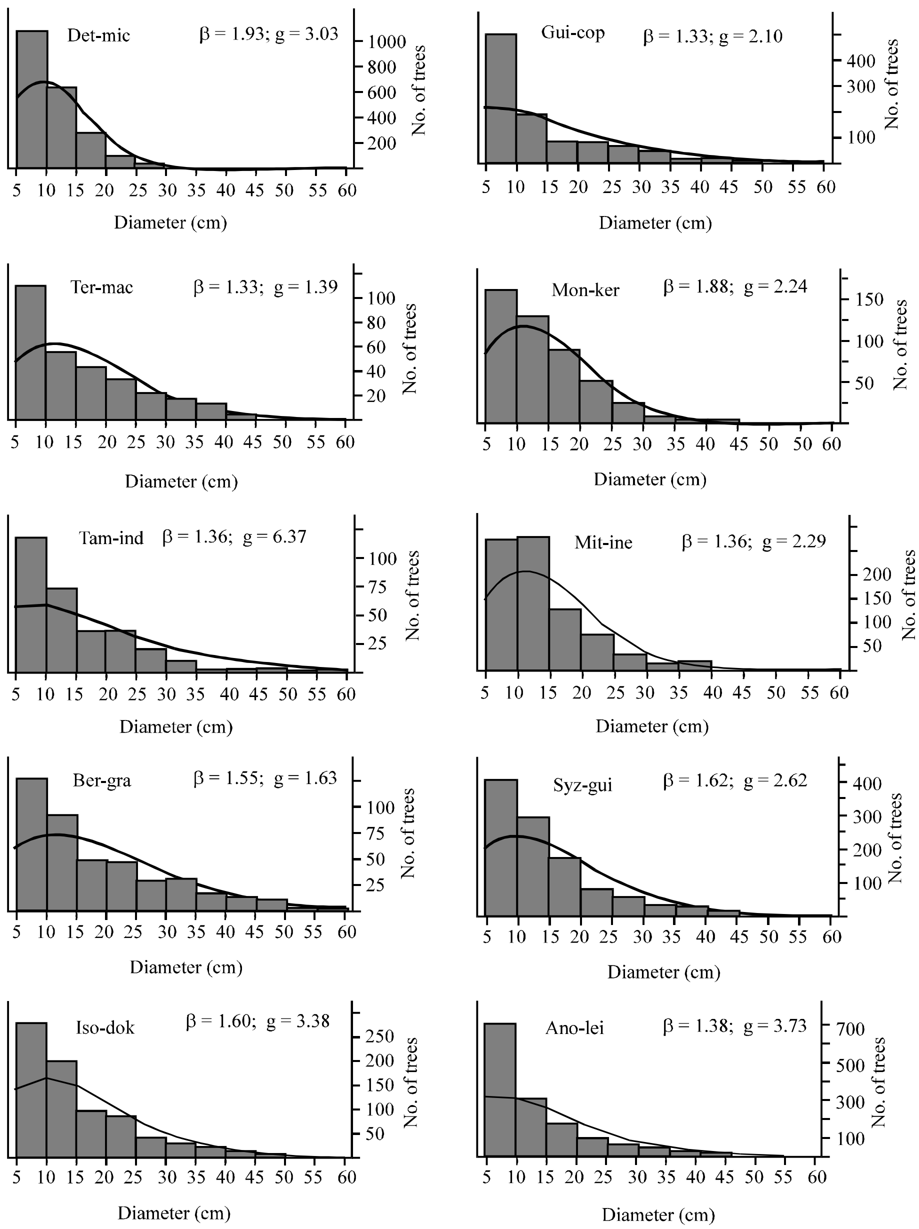

Fig. 7: Size class distribution of woody vegetation in the ten plants' communities, Diameter class histograms and corresponding fitted weibull distributions (solid line) for Det-mic (*Detarium microcarpum*), Gui-cop (*Guibourtia copallifera*), Ter-mac (*Terminalia macroptera*), Mon-ker (*Monotes kertinjii*), Tam-ind (*Tamarindus indica*), Mit-ine (*Mitragyna inermis*), Ber-gra (*Berlinia grandiflora*), Sys-gui (*Syzygium guineense*), Iso-ber (*Isoberlinia doka*) and Ano-lei (*Anogeissus leiocarpa*) are presented. The x-axis is uniform and covers 5 cm size intervals of diameter measured at 130 cm in height. The actual tree number is shown on the y-axe. Weibull shape statistic (β) and skewness parameter (g) are included

between the six cited communities and then between Mit-ine, Mon-ker and Syz-gui. Tam-ind community had the highest density (Fig. 5) but the comparison of the density by pair indicated that Mit-ine and Mon-ker communities are similar such as Iso-dok Det-mic and Ter-mac communities. Ten plant communities had significantly a similar mean height (Fig. 6, d. f = 9; F= 1; p = 0.43), but the highest trees were found within Gui-cop (21.99%) and Syz-gui (5.86%) communities. The communities of Det-mic and Ter-mac were characterised by the shortest trees, respectively 35.40 and 20.45% (Fig. 6).

The diameter class distribution in all the plant communities showed a reverse "J" shaped curve and the Weibull function fitted to the diameter structure of all of them indicated a positive skew with $2.6<\beta<3.7$ (Fig. 7). The size class distribution of the plant communities showed a healthy population, with population dominated by the juvenile classes.

DISCUSSION

Taxonomic diversity and plant communities' composition: The overall species richness reported in this study accounts for around 46% of native woody species found in Burkina Faso and 64% of native woody species found in the Southwest of the country. Lebrun (1991) reported that the woody flora (trees, small shrubs and climbers) at the country level includes 55 families, 214 genera and 376 species (with 96 exotic species) and Ouoba (2006) recorded more than 200 woody species in the Southwest of the country. The classified forest of Comoe-Leraba is a mosaic of patches of different ages produces by disturbances of different magnitude. In fact, the forest is composed of two classified forests (Diefoula and Logoniegue) with different histories. The classified forest of Diefoula was stated on the 29th November 1937 and Logoniegue on the 4th August 1955. So, heterogeneity in ecological conditions due to multiple disturbance regimes allowed coexistence of many species with different niches and also due to the natural ecological conditions which are govern by soil type, the topography and the water condition.

As far as the composition of the plant communities is concerned, the higher the importance value index (IVI) is, the more the indicator species is abundant and may form a monospecific community. This is the case of Gui-cop, Mit-ine and Ter-mac communities.

The most common and dominant families were Ceasalpiniaceae, Combretaceae and Rubiaceae, a pattern found in most woodland mosaics of the country (Fontes and Guinko, 1995; Bognounou *et al*., 2009). The Caesalpiniaceae family, particularly dominates the species composition of the whole south-sudanian zone by the genera of *Isoberlinia* and *Detarium* (Guinko, 1984). In contrast, present results indicate that the Rubiaceae family dominates the Comoe-Leraba classified forest, which occurs at the highest level of rainfall gradient of the whole country. It is most important genera are *Mitragyna*, *Gardenia*, *Crossopteryx*, *Pavetta* and *Morelia*. Two of the well known genera *Isoberlinia* and *Detarium* come in fifth and fifteenth position in terms of dominance in the whole comoe-leraba classified forest (Table 2). The Iso-dok and Det-mic communities have been more affected by cultivation than others, according to our observation during the investigation and evidence gathered with local people. Iso-dok sites' are usefull in yams cultivation (Guinko, 1997; Dourma *et al*., 2009) in this area and Det-mic sites for cultivation of cereals and groundnut. Nowadays old lofts, agricultural mounds and old stools can be found in these places suggesting disturbance and anthropogenic influences on *Detarium* and *Isoberlinia* sites.

In the case of present study area the Ceasalpiniaceae family is the second most dominant family, with the abundant apparition of another species, *Guibourtia copallifera*. The presence of this species suggests some local different ecological conditions (Rowland and White, 2010) compared to other parts in the south-sudanian zone. This species is more frequent in the guineo-congolian zone. It reflects that present sampling occurred in close proximity guineo-congolian zone.

Plant communities' diversity: Differences in species richness and the diversity of plant communities result from variations in the soil types, topography, microclimate (Guinochet, 1973) and from the degree and frequency of disturbance. Det-mic has high number of species compared to other communities. Vegetation clearing for cultivation may change environmental conditions. When an area is disturbed, species that grow well in the new environment may recruit and establish, increasing the number of species (Banda *et al*., 2006; Ajbilou *et al*., 2007). This may change over time as species that cannot tolerate the new environmental conditions eventually die off (Banda *et al*., 2006). Better moisture availability during the dry season in Syz-gui, Ber-gra and Ano-lei communities may allow high species richness these habitats (Breshears and Barnes, 1999). In addition, the species in these communities has been spared from fire. Mon-ker, Tam-ind and Iso-ber have medium species richness. Termite mounds have been identified as safety site for woody in woodland savannah (Traore *et al*., 2008). But most of the biological types in Tam-ind are lianas and most of the time their diameters don't reach 5 cm (DBH). Concerning Mon-ker, rocky and shallow soil cover inadequate to support woody growth can explain its medium richness. These kinds of surfaces support sparse species-poor vegetation (Ayyad *et al*., 2000).

The communities with low species richness Mit-ine, Ter-mac and Gui-cop depend on environmental obstacle such as inundation and shadow. For instance, the diversity of the Mit-ine and Ter-mac communities has temporarily high ground water levels and many species are asphyxiated (Sinsin, 1993; Veneklaas *et al*., 2005; Ouedraogo *et al*., 2008) leading to a low number of species in these plant communities. Gui-cop has a high canopy cover (95-100%). However, light is an important abiotic parameter for seed germination (Lawton, 1990; McGuire *et al*., 2001). In this case only species sported germination and growth with little light can be established. Low-light demanding species have minor effect on phytodiversity (Huang *et al*., 2002).

On one hand, the similarity was high between some plant communities and on the other hand it was fairly low between other communities. Thus, the classified forest of Comoe-Leraba has high beta diversity and that accentuates the importance of patches and classified forests in maintaining high species diversity at larger spatial (landscape) scales. The classified forests deserve special attention because they constitute the most biologically diverse terrestrial ecosystems of the country.

A consequence of the high diversity found in the classified forest is that many species occur at very low densities. Some of these species are threatened with extinction through disturbances (deforestation, fire, wood logging, ecosystems loss...). Efforts to conserve classified forests face an uphill struggle because the features described above (species in low densities, patchiness and disturbance patterns) combine to dictate that reserves (protected areas) need to be large. Large reserves are likely to contain more species, more patches and more endemics than smaller reserves. In large reserves, disturbances may occur in one part of the reserve and not others.

Plant communities' stand structure: The basal area is lower in Det-mic and Iso-dok communities than in all other communities, because of heavy chopping for cultivating. Newly recruited stems have slim trunks. Many of them are below 5 cm dbh which resulted in this lower basal area. In addition, the density is also low in these two communities. In the agrosystem of villages, they don't eliminate all trees in the field; some useful species are protected (Yameogo *et al*., 2005). But compared to Det-mic, Iso-dok has got a high density. This is due to the fact, that during yams cultivation trees are saved and are used as stakes (Dourma *et al*., 2009). In the case of *D. microcarpum* its high sprouting capacity (Bationo *et al*., 2000) helps to quickly recover the post-agricultural areas in the Comoe-Leraba protected area.

Concerning the mean diameter, we noted that Det-mic is characterized by a lower mean diameter than the other communities. It means that we have a higher juvenile population than in communities with mostly mature trees. The number of stems measured in each community depends on the plot size. For example the microhabitat of termite mounds is much smaller than others, following by the string-course of rivers but if we look for the density they are not the less dense communities of the protected area. In the woodland savanas (Ter-mac, Iso-dok, Mon-ker and Det-mic), we have lower number of stems than in the riparian forests (Syz-gui), the dry forests (Ano-lei) and the islands of rain forests (Gui-cop). As a sudanian zone the densest communities are not the most distributed in the area, like the savannah (White, 1983). So, the number of stems recorded in these communities comparing to the woodland savannah, is necessarily lower. The density was different between the plant communities but their stand structures were almost similar-a reverse "J" shape curve structure- indicating an excellent regeneration. In the reverse "J" shape curve structure, the mortality is compensated by the growth of the individuals from the low size classes. Many authors consider this structure as the ideal stable plant population because it maintains itself (Peters, 1997; Zegeye *et al*., 2006). There are a large number of juveniles in the low classes, showing a potential renewal of the communities (Peters, 1997; Teketay, 1996; Zegeye *et al*., 2006). Seedlings establishment is an important part of vegetation dynamics, as the recruitment of seedlings determines the composition of the future population (Vieira and Scariot, 2006). According to Peters (1997) the ultimate criterion according to which the biological strategy of plant species must be estimated is their capacity to recruit new juveniles to maintain their population. But, these juveniles are affected by highly variable precipitation, frequent dry periods, grazing and fire which are important causes of mortality (Marod *et al*., 2002; Menaut *et al*., 1995; Swaine, 1992; Vieira and Scariot, 2006). This situation makes the juveniles' survival unpredictable because of complex interaction among soil, climatic conditions and regeneration mechanisms.

CONCLUSION

The Comoe-Leraba reserve has relatively high species richness and beta diversity. The plant communities have an excellent regeneration dynamic. But, this reserve like all reserves deserves special environmental attention because in some patches, a few species are common and many are rare. The integrated management of the protected areas should be applied for all the protected areas with better participation of the surrounding populations for biodiversity conservation.

ACKNOWLEDGMENTS

We acknowledge the logistic and financial support from the BMBF through Biota West Africa program. We thank the administration of AGEREF which allowed us to perform this study in their area. We thank the Minister in charge of Environment in Burkina Faso for the logistic support. Thanks are also due to field assistants for their help during the field work. The important work of species identification of Pr Laurent Aké ASSI is highly appreciated.

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