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Protected versus exploited savannas: characteristics of the Sudanian vegetation in Ivory Coast

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ABSTRACT

KOULIBALY, A., D. GOETZE, D. TRAORÉ & S. POREMBSKI (2006). Protected versus exploited savannas: characteristics of the Sudanian vegetation in Ivory Coast. *Candollea* 61: 425-452. In English, English and French abstracts.

In tropical Africa, savannas occupy vast areas in the Sudanian region and in its transition to the Guineo-Congolian region. Various forms of human activities have increasingly disturbed these ecosystems over recent decades and ecological problems have evolved from the increasing exploitation of the natural resources. This paper examines the anthropogenic impact on the plant diversity, structure and phytomass of herbaceous to woody savannas in protected and exploited areas. A management perspective is proposed. The study sites were located in the Comoé National Park (CNP) and in the Korhogo town regions in the North of Ivory Coast. Several vegetation parameters were studied with standardised ecological methods on 19 surfaces of 1000 m^2. In both regions, the most important families in terms of the number of individuals were *Fabaceae*, *Rubiaceae* and *Caesalpiniaceae*. However, the plant diversity was twice as high at the species level in the CNP. At Korhogo, there was a higher proportion of species from the other floral regions including the newly introduced species. In this region, the degradation of the vegetation became obvious by the absence or the low coverage of the upper strata in contrast to the CNP. Basal area and biomass of the studied savanna plots in the CNP were higher than in the Korhogo region, showing the occurrence of a few large tree individuals contributing to the total biomass of a plot by up to 89%. In both regions, only the species protected (and used) in the local customs were represented by the old-growth individuals. The traditional protection by the local population reveals, in a relic form, the aspect of the vegetation before its exploitation; the eventual application of this type of protection, before establishing a reserve, will probably give the best result in the CNP. A complete protection of the areas that had been subjected to intensive coppice cutting may allow for a substantial restoration of the woody biomass. These facts may be used to increase for the local inhabitants' growing awareness of a more sustainable land management.

RÉSUMÉ

KOULIBALY, A., D. GOETZE, D. TRAORÉ & S. POREMBSKI (2006). Savanes protégées contre savanes exploitées: caractéristiques de la végétation soudanienne en Côte d'Ivoire. *Candollea* 61: 425-452. En anglais, résumés anglais et français.

En Afrique tropicale, les savanes occupent de vastes surfaces dans la région soudanaise et sa zone de transition avec la région guinéo-congolaise. Durant les dernières décennies, différentes formes d'activités humaines ont affecté ces écosystèmes et des problèmes sont apparus suite à l'exploitation

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croissante des ressources naturelles. Ce travail évalue les conséquences anthropiques sur la diversité floristique, la structure et la phytomasse des savanes herbacées à boisées en comparant les milieux protégés et exploités. Des perspectives d'aménagement sont proposées. Les sites d'étude sont localisés dans les régions du Parc National de la Comoé (PNC) et de la ville de Korhogo dans le nord de la Côte d'Ivoire. Plusieurs paramètres de végétation ont été étudiés avec des méthodes écologiques standardisées dans 19 surfaces de 1000 m². Dans les deux régions, les familles les plus importantes en termes de nombre d'individus sont les *Fabaceae*, *Rubiaceae* et *Caesalpiniaceae*. Cependant la diversité floristique spécifique était deux fois plus élevée au PNC. A Korhogo, il y a une plus grande proportion d'espèces appartenant à d'autres régions floristiques et comprenant des espèces nouvellement introduites. Dans cette région, la dégradation de la structure de la végétation est perceptible par l'absence ou la faible couverture des strates supérieures en contraste avec la région du PNC. L'aire basale et la biomasse des parcelles de savane étudiées au PNC étaient plus élevées que dans la région de Korhogo, indiquant la présence de quelques individus de gros diamètre pouvant contribuer à la biomasse totale d'une parcelle jusqu'à 89%. Dans les deux régions, seulement les espèces protégées (et utilisées) dans les traditions locales étaient représentées par les individus gros les plus âgés. La protection traditionnelle par la population locale fait apparaître, à l'état relictuel, ce qu'était la végétation en des temps plus anciens, c'est à dire avant son utilisation; l'application probable de ce type de protection dans le PNC, avant qu'il ne soit établi en réserve, donnera le meilleur résultat. Une protection complète des surfaces ayant subi des coupes intensives conduit à la restauration de la biomasse ligneuse de façon considérable. Ces faits peuvent être utilisés pour accroître la sensibilisation des populations locales à une meilleure gestion des ressources naturelles.

KEY-WORDS: Biodiversity – Biomass – Conservation – Land use – Land management – Vegetation structure – Africa

Introduction

In tropical Africa, savannas occupy the Sudanian region and the adjacent transition zone to the Guineo-Congolian region (White, 1986). Savanna is a tropical formation where a grass stratum is continuous and includes fire-tolerant trees and shrubs to a greater or lesser extent (Lamotte, 1985). According to the height and the cover of trees, savannas were classified in different physiognomical types for the whole Africa continent (Trochain, 1957). Their distribution commonly forms a mosaic across the landscape. Some functional characteristics of savannas were studied in Africa (Huntley & Walker, 1982; Menaut, 1983; Solbrig & al., 1995; Furley, 1997). Most Sudanian savannas in West Africa are considered to be of anthropogenic origin, deriving in principle from dry forests (Aubréville, 1949; Schnell, 1952; Backéus, 1992; Badejo, 1998; Guinko & Belem, 1998). Lykke (1998) has shown that various human activities have disturbed the savanna ecosystems for a long time. Especially over the last one hundred years, these disturbances have increased (Hoffmann, 1983). The savannas are a resource for food, medicine, timber and livestock breeding for the greater part of the local inhabitants (Bellefontaine & al., 1997).

In Ivory Coast, the savannas are distributed in the center (Guinean savanna) and in the North of the country (Sudanian savanna) (Guillaumet & Adjanohoun, 1971). In these savannas, the excessive exploitation of wood resources is associated with cutting and burning before cultivation, short fallow periods of mostly 2–5 years, extending plantations, abusive practices of burning and sometimes grazing. The exploitation of the biological resources is clearly shown by the present broadening of the mosaic of fields and fallows.

Beside the plantations of cotton in Northern Ivory Coast, the agricultural practices have remained manual. Farmers cut and burn the trees to set up fields, but they also protect a few trees for use or for traditional grounds. They cultivate staple crops such as *Dioscorea* spp., *Oryza sativa*, *Zea mays* and *Arachis hypogaea*, and practice arboriculture of *Mangifera indica* and *Anacardium occidentale*. There is also sylviculture of *Tectona grandis*, *Gmelina arborea* and *Eucalyptus* spp. Up to the 1940s, the savanna trees were not officially considered to produce wood of sufficient quality for logging (Catinot, 1994). Scientific research concerning the North of the country was even downgraded by the Ivorian government (Aké Assi & Boni, 1990).

Therefore, savanna studies have focused first and foremost on the Guinean savannas in the Lamto Reserve. This reserve consists of savanna which deeply penetrates into the rain forest zone in the South despite the climatic conditions favourable for mesophilous formations. The principal works that have contributed to the knowledge of flora and vegetation structure are Roland & Heydacker (1963), Portères (1966), Vuattoux (1970), César (1971) and Menaut (1971). The dynamics of the woody cover were studied for the forests by Devineau (1973, 1975) and for the savannas by Abbadie (1984) and Devineau & al. (1984). Numerous studies on the savannas' productive capacity were carried out by César (1981, 1990) and included the comparison of areas along the climatic gradient from Ivory Coast to Burkina Faso such as the Lamto Reserve (Guinean zone), the Comoé National Park (CNP) (southern Sudanian sector) and Nazinga (central Sudanian sector) by Fournier (1991). Using recent aerial photographs of forest-savanna edges, Dugerdil (1970a, 1970b), Guillaumet & Adjanohoun (1971), Blanc-Pamard & Spichiger (1973), Spichiger (1975), Hiernaux (1975) and Gautier (1989, 1990) confirmed that in spite of annual burning of the savanna surfaces, the forest advances into savanna in central Ivory Coast. Other studies carried out elsewhere agree with this finding (Hopkins & Jenkin, 1962; Miège, 1966; Profizi, 1982; Moutsambot, 1985; Guinko & Belem, 1998). For Moutsambot (1985) and Guinko & Belem (1998), the agricultural activities may favour a re-establishment of the forest instead of the savanna. This is different in the forest-savanna pattern of the climatically drier CNP region. It tended to be stable under semi-natural conditions (Goetze & al., 2006).

However, some researchers often considered the human influence as a factor of "savannisation" (Aubréville, 1947; Adjanohoun, 1964; Guillaumet & Adjanohoun, 1971; Paradis & Houngnon, 1977; Hoffmann, 1983). They showed that the expansion of savanna was due to an intensive land use in the forest-savanna mosaic in the Centre and the Northeast of Ivory Coast, as well as in Benin under similar conditions. Among the few contributions on the savannas in the North of Ivory Coast, Adjanohoun & Aké Assi (1967) described the floristic diversity. César (1978), Bruzon (1986), Fournier (1991) and Poilecot & al. (1991) concluded that the herbaceous strata of Sudanian savanna has a large nutritional potential for livestock farming. Hoffmann (1983) identified the impact of exploitation by the Lobi population on the phytomass production in Doropo in the extreme Northeast of the country. Mitja (1992) described the dynamics of the post-cultural vegetation in a humid savanna area in the Northwest. Louppe & al. (1995) carried out the first experiments relative to the impact of the forest burning on the floristic diversity in the Korhogo region.

In the papers cited above, except Hoffmann (1983), the conclusions on the effects of land use on vegetation were derived from studies considering exploited or protected areas separately without relating them to each other. However, for evaluating anthropogenic impact, data from exploited areas have to be compared to undisturbed sites where ecological conditions are as natural as possible, serving as a reference. Therefore, this paper compares vegetation data recorded in protected savanna inside the CNP with data recorded from intensely exploited savanna around of Korhogo. The effects of land use pressure increasing in many places in the Sudanian zone is documented and analysed regarding the development of a more sustainable land management urgently needed in the Sudanian zone.

In this paper we address what questions relative to (1) the effects of the land use on diversity and structure of savanna in comparison with a corresponding protected area; (2) the land management practices necessary in order to get a more sustainable use of the savanna ecosystems.

Material and methods

Study Area

The study sites are located in the sub-Sudanian sector of the Sudanian domain of Ivory Coast (GUILLAUMET & al., 1971; Fig. 1A) which is in general characterised by savannas and decidous forests. Some semi-deciduous forests are present on the plateaus and generally in their surroundings (AUBRÉVILLE, 1947; MIÈGE, 1955; SPICHIGER, 1975). The other numerous dense forests are observed in the South of the 9th parallel (ADJANOHOUN & AKÉ ASSI, 1967). Some gallery forests also occur in the savanna area (ARNAUD & SOURNIA, 1979). Located on the large granite stand of West Africa, Northern Ivory Coast is characterised by a smooth and level relief. The bedrock of our study sites is composed of schists and granites (ELDIN, 1971). Soil distribution follows accurately the distribution of bedrocks which underlay a ferralitic evolution during the quaternary. Originating from granite bedrock, ferruginous soils have been recently transformed to ferallitic substrata which are acidic (pH 4–6) (AVENARD, 1971). The hydrography is formed by the large rivers Comoé and Bandama and the majority of backwaters which dry up in the dry season. The North of Ivory Coast is occupied by the populations of Sénoufo, Malinké, Peulhs, Koulango and Lobi. General land uses are agriculture, coppicing, seasonal burning and sometimes grazing. Bush and savanna fires annually pass through in a large part of the region.

Climate

The mean annual rainfall was recorded by the FAO AGROMETEOROLOGY GROUP (2000). It was 919 mm in Dabakala (the nearest climate station to the CNP study region) between 1971 and 1996 (Table 1). FISCHER & al. (2002) recorded a mean annual precipitation of 1050 mm in the southern part of the CNP from 1993 to 2000. In the Korhogo region, the average annual rainfall was 1235 mm from 1971 to 1996 (FAO AGROMETEOROLOGY GROUP, 2000).

In the whole Sudanian sector of Ivory Coast, large interannual variations in rainfall occur (ELDIN, 1971; COULIBALY, 1977). In the CNP region, the annual deviation of total precipitation may reach 40% (FISCHER & al. (2002) and is higher than in the Korhogo region. These interannual variations are primarily caused by irregularities in rainfall during the peak of the rainy season which are much more pronounced in the CNP region (Table 1). During a period of only a few weeks in July and/or August, precipitation may temporarily drop to very small values leading to a notably smaller amount of total rainfall in that year and accounting for the high annual variations in the CNP region. There is not sufficient knowledge on the effects these variations may have on ecosystems as, in general, the drier intervals occur only within one of the seven or eight months of the rainy season.

In both study regions, the rainy season lasts from March or April until the end of October. The mean annual temperature is around 27° C. A fresh and dry wind called "Harmattan" blows for up to three months during the dry season. An annual hydric deficit of 600 to 850 mm was recorded until the 1960s. Its values strongly depend on the intensity of the Harmattan (ELDIN, 1971).

Comoé National Park (CNP)

Our study was carried out in the southern part (8°41'-44' N and 3°47'-51' W) of the CNP (Fig. 1B) which has been protected and uninhabited since 1926 (POILECOT & al., 1991). This part of the park is an upland plain located at 200 to 300 m a.s.l. We determined the soils to be ferralitic and poor in nutrients. Savanna types range from grass savanna to savanna woodland (89.1% cover). Semi-deciduous forest islands (8.4% cover) are scattered in the savannas, and gallery forests (2.3% cover) follow the permanent and ephemeral water courses (FGU-KRONBERG, 1979). In the savanna, *Andropogon* spp., *Loudetia* spp. and *Hyparrhenia* spp. are the dominant grass genera while *Terminalia* and *Combretum* are frequent woody genera. Human activities consist of setting seasonal fires and poaching all larger savanna animals. The study sites are located within a so-called biodiversity observatory of the BIOTA Africa research programme. It is one of the numerous monitoring surfaces of 1 km^2 that have been set up in several parts of Africa.

Korhogo area

The Korhogo area is located in a densely populated zone (30.8 inhab./km^2). Korhogo is a town with a rapidly growing human population (150 000 inhabitants in the early 1990s; BONETTI, 1998) and surrounded by numerous small villages. The study site is located between 9°22'-34'N and 5°32'-39'W. The region is characterised by plateaus (300 m a.s.l.) and inselbergs. The ferralitic soils in this region were developed through the alteration of granite bedrock (PERRAUD & al., 1971). The dry season lasts from November to April. The naturally occurring Sudanian savanna (MONNIER, 1973) is constituted of the frequent woody species *Parinari curatellifolia*, *Swartzia madagascariensis, Detarium microcarpum* and the dominant grass genera *Andropogon* spp. and *Hyparrhenia* spp. Some semi-deciduous forests like sacred forests are located near the villages. As they were hunters in the past, the dominant ethnic group Sénoufo migrated into this area supposedly in search for favourable land for agriculture (COULIBALY, 1977). In the vicinity of the town, vegetation has been strongly altered due to the intensive land use. The study sites are located three to five kilometres away from the town near its arterial roads (Fig. 1C).

Vegetation structure mesurements

The biodiversity observatory in the CNP has a surface of 1 km^2 comprising – besides forests – different types of savanna. This area was divided into 100 1-ha plots. Fourteen of the savanna plots were selected by a stratified ranking procedure to serve as sampling areas. Field data were recorded from July to December 2001 (late rainy period). Around Korhogo, 4 1-ha plots were installed in exploited open shrub and shrub savanna and one in a tree savanna which had been protected for ten years. The locations were selected in the field by homogeneity of vegetation. Data were recorded from July to December 1999.

In order to determine the overall plant diversity, all vascular plant species were recorded within the whole 1-ha surfaces. The names of taxa were taken from LEBRUN & STORK (1991-1997), life forms from RAUNKIAER (1934) and the chorological affinities from LEBRUN (1981) and AKÉ ASSI (1984, 2000, 2001).

Vegetation structure was assessed with relevés of the percentage cover of vegetation strata in predefined intervals in the CNP and with linear relevés in the Korhogo region. The linear relevé-method is a combination between the *linear transect method* used by BUELL & CANTLON (1950) and DEVINEAU (1984), and the *point contact method* used by DAGET & POISSONNET (1971). It was adopted by GAUTIER & al. (1994) and first applied to tropical forests by CHATELAIN (1996) and KOUAMÉ (1998) (Fig. 2). Here, it was applied to Sudanian savannas for the first time. For direct comparison, the data recorded were subsequently classified according to the intervals applied to the CNP data.

The biomass of all the woody plants taller than 2 m was determined by means of the basal area S, calculated from measures of the trees' diameter at breast height (DBH) and their total height in the field. This was done for selected sites of 20 × 50 m^2 located in the 1-ha plot (Fig. 2).

Basal area $S = \sum_{1}^{n} D_i \times D_i \times \pi/4$, where:

i – woody individual;

n – total number of woody individuals;

D – diameter of woody individual at breast height [m].

$$\text{Biomass } P = \sum_{1}^{n} S_i \times H_i \times 0.56 \times 0.65, \text{ where:}$$

S – basal area [m^2/ha];
H – total height of woody individuals [m];
0.56 – natural coefficient for stem shape (DAWKINS, 1961);
0.65 – mean woody density in the region (DEVINEAU, 1984);
i – woody individual;
n – total number of woody individuals.

Results

Floristic analysis

The overall plant diversity was clearly higher in the CNP with 53 families, 147 genera, and 199 species compared to 50 families, 109 genera, and only 132 species in Korhogo. The range of the six dominant families were very similar with *Fabaceae*, *Caesalpiniaceae*, *Rubiaceae*, *Poaceae*, *Euphorbiaceae*, and *Combretaceae* being the most abundant (Fig. 3). Only the *Poaceae* were four times more abundant in the CNP. In both sites, 272 species were recorded, with 61 of them common to both regions (Appendix 1).

The life form spectra of both regions, calculated by the percentage of species abundance, included all the major types and were clearly dominated by the phanerophytes (Fig. 4). While the absolute numbers of phanerophytes were similar, the other life forms such as chamaephytes, hemicryptophytes, therophytes and geophytes were represented only half as much represented at the Korhogo sites.

The phytogeographic relationships belonged to the Sudano-Zambezian type for about one third of the species recorded and to the Guineo-Congolian type for about one tenth of the species (Fig. 5). About half of all the species and thus the large majority showed an intermediate type of distribution. In the Korhogo region, there was a higher proportion of species from other floristic regions due to the species newly introduced for economic purposes. Most important among them were the timber trees *Tectona grandis* and *Gmelina arborea*, and the fruit trees *Mangifera indica* and *Anacardium occidentale*.

Structure analysis

General differences in vegetation structure between both regions were obvious for all the vegetation strata. Considering all the strata above 2 m, higher percentages cover were recorded in all the savanna types in the CNP (Table 2). The savanna type with the highest woody cover in the CNP, the savanna woodland, was missing in the Korhogo region. Thus, the increase in cover at higher vegetation strata when moving from grass savanna to tree savanna was much more pronounced in the CNP.

At the lowest stratum (0 to 2 m), the percentage cover was always higher than that of the strata above. In general, this is due to the presence of numerous young shoots of the woody species produced as a reaction to annual biomass loss due to burning or cutting. Consequently, this stratum is generally occupied by *Daniellia oliveri*, *Detarium microcarpum*, and *Bridelia ferruginea*.

In the Korhogo region, vegetation taller than 2 m was scarce or sometimes fully missing, and the strata had irregular distributions as a direct consequence of traditional practices according to which individual species were protected in the field. In the recently protected tree savanna plot near Korhogo, a higher cover of the stratum 2–5 m showed notable stem shoot regeneration of the formerly cut trees and the development to a more forested savanna under protection. While vegetation in the CNP was usually 10 to 20 m high due to old-grown tree individuals of *Khaya senegalensis*, *Cola millenii*, *Isoberlinia doka*, it scarcely reached 10 m in the surroundings of Korhogo, with *Vitellaria paradoxa*, *Parkia biglobosa*, and *Albizzia zygia* dominating the woody layers.

Although the woody individuals taller than 2 m mostly had a higher cover in the CNP, the densities of their sprouts were considerably higher in all the corresponding savanna types studied in the Korhogo region, reaching up to 1595 individuals per hectare in the area recently protected. This was due to the notable resprouting after the formerly intensive coppicing. In this protected area of Korhogo, fire was rare during the first years of protection and then was totally suppressed.

Biomass

In contrast with Korhogo, the biomass of woody plants was higher in the shrub and tree savanna of the CNP (Table 3). Here, the presence of a few large tree individuals fundamentally contributed to the total values. This becomes even more evident when considering the basal area and biomass values of the CNP tree savanna and savanna woodland. Subtracting the values of the one or two largest individual trees of each plot from the biomass totals yielded differences of up to 89%. This applies also to the exploited grass savanna plot at Korhogo. Here, very few but large tree individuals contributed to the biomass values of the savanna, indicating a particular type of exploited savanna in the Korhogo region. The tree species which contributed most to the biomass values were, in the CNP, *Isoberlinia doka*, *Khaya senegalensis*, *Daniellia oliveri* and, in the Korhogo region, *Parkia biglobosa*, *Cassia sieberiana, and Cola cordifolia* which is often found in forests. These species are used or traditionally protected by the inhabitants.

Discussion

Protected area in the CNP

The floristic composition of the studied CNP savanna corresponds well to the vegetation generally described from the Sudanian zone of West Africa. The dominance of *Fabaceae*, *Rubiaceae*, *Caesalpiniaceae* and *Poaceae* in the CNP is in accordance with the descriptions of the whole Sudanian zone by ADJANOHOUN & AKÉ ASSI (1967) and GUILLAUMET & ADJANOHOUN (1971). Species frequently recorded in the CNP such as *Andropogon* spp., *Hyparrhenia* spp., *Terminalia* spp., *Combretum* spp., *Daniellia oliveri*, *Parinari curatellifolia*, and *Detarium microcarpum* are also the frequent ones in the Sudanian savanna vegetation (ADJANOHOUN & AKÉ ASSI, 1967; CÉSAR, 1978; WHITE, 1986; FOURNIER, 1991; MITJA, 1992; NEUMANN & MÜLLER-HAUDE, 1999; DEVINEAU, 2001).

The Guineo-Congolian species are generally enclosed in the forest relics and the gallery forests of the climatic dry zones (GUINKO & BELEM, 1998; POREMBSKI, 2001). In the CNP, the species with a Guineo-Congolian distribution, such as *Dialium guineense*, *Tapura fischeri*, *Salacia* spp., were more present around Korhogo despite the slightly drier climate. Furthermore, the proportion of transitional species in the savanna was higher (55%), indicating a more closed and less disturbed vegetation cover at the CNP site. Also, the proximity of the Comoé river and the presence of forest islands in the savanna might be contributing factors. FOURNIER (1991) observed a similar situation in the boundary zones of different vegetation types where the species richness was raised by the juxtaposition of the different plant chorological types.

The high proportion of *Poaceae* in the CNP was already noted by POILECOT & al. (1991). The *Poaceae* also strongly dominated by the herbaceous layer of the Nazinga and Lamto savannas (CÉSAR, 1971; FOURNIER, 1991). In contrast to the Sudanian zone of Ivory Coast where therophytes dominate over phanerophytes (ADJANOHOUN & AKÉ ASSI, 1967), phanerophytes were more abundant than therophytes in the CNP. However, the number of therophytes was still large.

The large number of phanerophytic individuals in the CNP shows that these may reproduce by notable regeneration through coppice and sucker growth. This is an important mode of quantitative regeneration towards the original vegetation (CATINOT, 1994). A low number of therophytes was also recorded from the Lamto Reserve by MENAUT & CÉSAR (1982) who concluded that the poor representation of therophytes might be due to the weak competitive ability of their seedlings in contrast to the faster growing of the perennials during the beginning of the rainy season. In the CNP, in comparison with the data of POILECOT (1991), the relatively low number of therophytes observed may be due to the less hydromorphic soil conditions present in the study sites. These soils are less favourable to the development of therophytes which survive dry conditions solely in the form of seeds.

In the CNP, the upper tree stratum may reach 20 m in height compared to 16 m in the Lamto Reserve and only 10 m in other humid savannas like in the Olokemeji Forest Reserve in Nigeria (HOPKINS & JENKIN, 1962). At the same time, the stem densities in the CNP savanna were lower than those around Korhogo or in Lamto where they can reach 1500 stems ha^{-1} (MENAUT & CÉSAR, 1982). However, the densities observed in the CNP were still high in comparison with the coastal savannas of the Fathala Forest Reserve in Senegal which are climatically drier than the CNP, and where human activities are restricted to the harvesting of dead wood, fruits, leaves and herbaceous plants and to the grazing during certain periods (LYKKE & SAMBOU, 1998). The large trees contributing significantly to the biomass were the oldest ones in the CNP. SCHÖNGART & al. (2006) observed that *Daniellia oliveri* trees might be up to 368 years old. This species was also observed among the biggest trees in the savanna of the Lamto Reserve protected since 1962 (VUATTOUX, 1970). KEAY (1952) showed in Nigeria that such trees, except sometimes for *Isoberlinia doka*, were well resistant to dry season fires. Biomass values in the CNP were very close to those recorded in Lamto according to the data of MENAUT (1973) on shrub and tree savannas.

Human disturbance in the Korhogo area

Korhogo is located in one of the most populated parts of Ivory Coast where the effects of agricultural activities on vegetation are considerable (GUILLAUMET & ADJANOHOUN, 1971). The Sénoufo cut almost all trees in order to allow sufficient light to fall onto the yam fields which provides the staple food for this people. Hence, the distribution of species seems to be determined by human activity rather than by the natural environment. This leads to artificial landscapes strongly related to social and cultural habits of the local populations. In this context, useful species that are protected such as *Vitellaria paradoxa* and *Mangifera indica* are growing in plantations and become more and more dominant in the landscape.

In the Korhogo region, the human impact leads to a lower species diversity, to a higher proportion of the Sudano-Zambezian species and to more irregular vegetation structures than described from other exploited places in North-Eastern Ivory Coast (HOFFMANN, 1983). Furthermore, life forms other than phanerophytes were weakly represented. This might be due to the less humid conditions in this region. Frequent and intensive land use in the Korhogo region has caused a considerable degradation of vegetation indicated by the lack of upper vegetation strata, the low vegetation richness and the largest tree individuals belonging to the traditionally protected species only. This shows that human activities have seriously modified the vegetation and the ecological conditions. The agricultural activities consist of growing food crops dominated by *Dioscorea* spp. and cereals like *Pennisetum* spp. (millet) and *Sorghum* spp. (sorgho). Monocultures of *Mangifera indica* and *Anacardium occidentale* have been planted because the incomes from the sale of the fruit are an important economic resource for the inhabitants. *Tectona grandis* and *Gmelina arborea* are grown as timber woods in monocultures. Naturally occurring and frequently used species of the Korhogo region are *Pericopsis laxiflora* and *Parinari curatellifolia* which are used in the dry season as firewood. For medicine, the leaves of *Sarcocephalus latifolius* are used in a decoction against fever, *Vitellaria paradoxa* is a component of numerous medicines, *Azadirachta indica* contributes to a medicine against malaria, and the roots and pounded stalks of *Vitex doniana* are used in the healing of wounds. The fruits of the common species *Parkia biglobosa* are eaten. The scarceness of some naturally abundant species such as *Pericopsis laxiflora* used for firewood and the omnipresence of other useful species like *Vitellaria paradoxa* provide evidence of the land use pressure on vegetation. The cultures have become permanent or semi-permanent in a circle of several kilometres around the town.

A corresponding degradation has been described from other places in West Africa (WHITE, 1986). In Senegal, Fathala Forest was replaced by savanna vegetation in some parts (LYKKE & SAMBOU, 1998). Large areas of evergreen dry forests have been cleared in the Sudanian zone establishing savannas (AUBRÉVILLE, 1949; CHEVALIER, 1951; GUINKO, 1984). In Burkina Faso, a contingent of Sahelian species (*Cassia tora*, *Sida cordifolia*, *Ziziphus mauritiana*) has advanced to the southern part of the country due to the clearing of land (GUINKO & BELEM, 1998). Among the 61 species observed in both regions (Appendix 1), there was a large proportion of widespread generalists like *Dichrostachys cinerea* and *Hymenocardia acida* which appear to be largely tolerant to disturbance and can grow on poor soils (DEVINEAU, 2001). A smaller number of species, such as *Sterculia setigera*, *Cassia sieberiana* indicate sites of a low anthropogenic disturbance level, while some species like *Guiera senegalensis*, *Securidaca longepedunculata*, *Trema guineensis*, *Sporobolus pyramidalis* colonise highly disturbed habitats like fallows and roadsides.

Human impact was also demonstrated by the intense resprouting after cultivation (cf. MONNIER, 1981; HOFFMANN, 1983) and the structural disruption of the upper vegetation strata. A comparable irregularity in the vertical vegetation structure was not found in the much more homogeneous CNP savanna. However, woody groves and grassy patches were reported from the wetter savanna in the Lamto Reserve (MENAUT & al., 1990). In the Korhogo region, a continuous intensive use of savanna might result in a severe degradation and fragmentation of the original savanna vegetation.

Conservation management

The similarity of the range of dominant families in the exploited and protected study areas demonstrates the phytogeographic coherence of the study zone. On the anthropogenically degraded sites, phytodiversity did not change at the family level. The general species richness of the savanna communities increased along the climatic south-north gradient by an approximated 30% between Lamto (6°N) and Nazinga (11°N) (FOURNIER, 1991). The number of species was also higher at Korhogo (9°N) than at Lamto (6°N). However, the latitudinal distance between Korhogo and the southern CNP amounts to only about 1° and is not likely to cause a notable difference.

According to general opinion, the environmental degradation due to the loss of biodiversity is related to agricultural activities. However, further direct causes of degradation can be fire and livestock breeding. In general, the present savanna vegetation is closely bound to the annual fires caused by man (FOURNIER, 1991). Human impact and habitat degradation are much stronger in drier savannas. Many studies were carried out on the consequences of burning on savanna vegetation, (BÉGUÉ, 1937; AUBRÉVILLE, 1953; CATINOT, 1994; MENAUT & al., 1995). They showed that a proliferation of stems of all diameters occurs without fire. Early and late fires do not have the same impact on trees of different stages of growth. The late fires kill small trees and cause damage to larger ones, and early fires cause less damage to any tree. Consequently, this is an important factor in the evolution of savanicolous formations (GAUTIER, 1990). Nevertheless fire is often less destructive to vegetation than the mechanical clearing of new agricultural surfaces because fire still leads to the spread of savanicolous vegetation. Concerning livestock breeding, recent studies revealed that, in contrast to farmers, livestock raisers who exploit some big livestock of zebu and small ruminants for milk and meat (AISA, 1991) are not "consumers" of forest, but follow rather than precede pioneer agriculturalists that clear forests for farming (BASSETT & BOUTRAIS, 2000; HOUINATO & SINSIN, 2000). In our context, these recent findings support the hypothesis that vegetation degradation in the Sudanian zone is essentially due to agriculture.

The presence of large tree diameters in the protected savannas may reflect two realities.

Firstly, it could be an aspect of the original vegetation before use. Until only a few years ago, vegetation was sacred for humans in Africa. The vegetation offered an ideal place for various traditional ceremonies. Nobody was allowed to cut trees arbitrarily, and sometimes large trees were believed to attract rain (LYKKE, 2000). These big trees might have been present in the original vegetation and were protected through traditional customs. Today, however, only a few of these protected tree species are left in disturbed savannas, like *Parkia biglobosa* and *Vitellaria paradoxa* in the Korhogo region.

Secondly, the effects of the traditional protection were likely to be the same inside of the CNP. This reserve might have been exploited by people in the past. Its savannas, and the tree savannas in particular, were subjected to historical cultivation and grazing pressures (POILECOT & al., 1991). The people might have applied their traditional practices in protecting some trees species. These trees represented the principal components of the original vegetation that the inhabitants tried to preserve. This might explain the similarities observed between the CNP and the exploited areas.

Moreover, the high woody plant densities often recorded in the exploited areas might be used for re-establishing former amounts of biomass, after coppicing, like in the protected plot studied at Korhogo.

The general development of the vegetation management in tropical dry zones is done according to their economic and social role. As a consequence, this allows for the necessity to learn to manage it sustainably (BELLEFONTAINE & al., 1997). A reasonable first step in developing a new policy. The inhabitants should be encouraged to extend their indigenous practices to the protection the exploited habitats and the functional species as they did in the past, as well as on other species known to be essential. This means that a management strategy has to be created that includes the origins of common traditional practices and which refers to the conservation and the use of the natural biodiversity.

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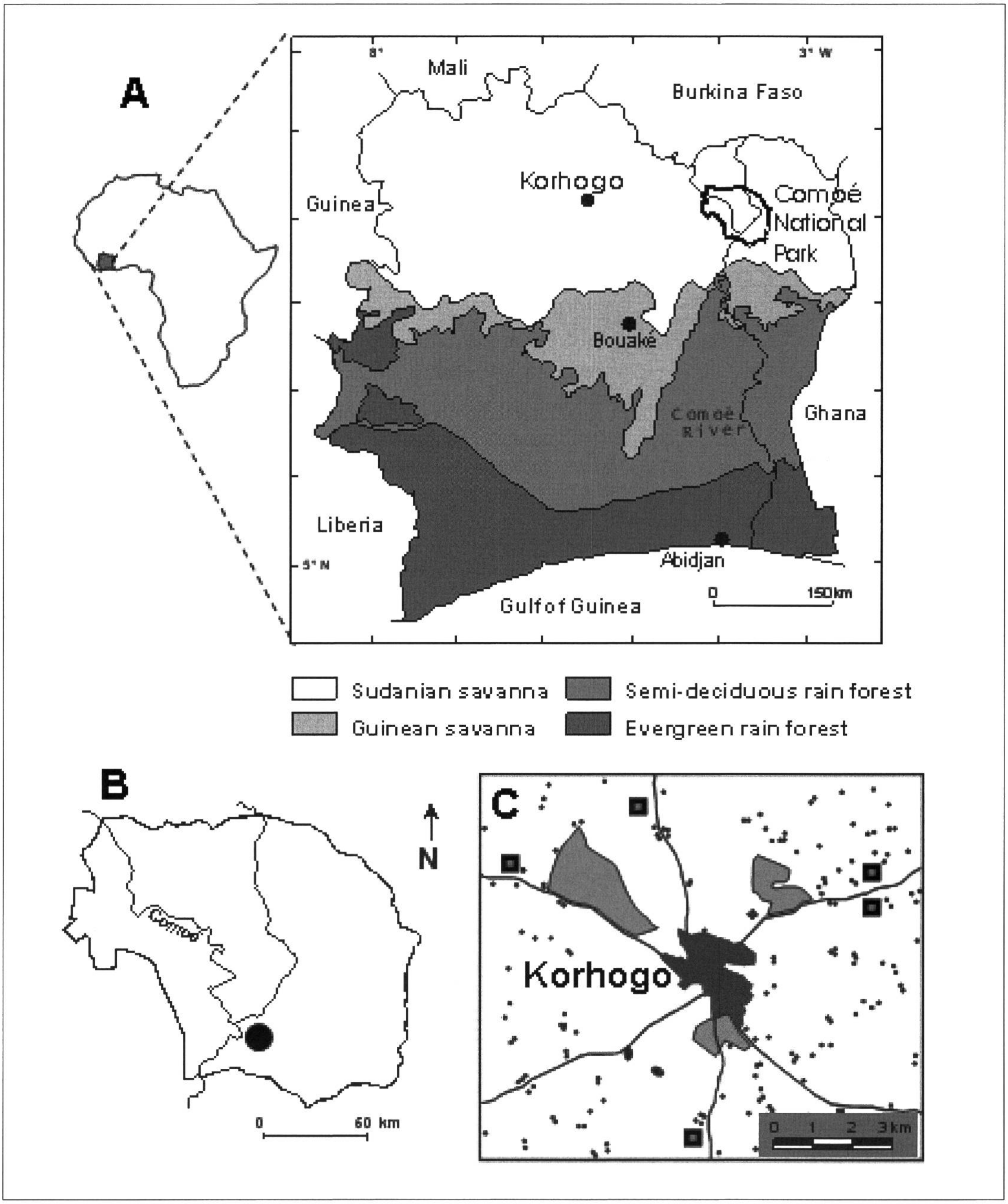

Fig. 1. – **A**. Distribution of the major vegetation zones in Ivory Coast. **B**. Location of the study sites. Biodiversity observatory in the Comoé National Park (●). **C.** Sampling plots in the Korhogo surroundings (■); grey surfaces: Classified Forests; black points: villages.

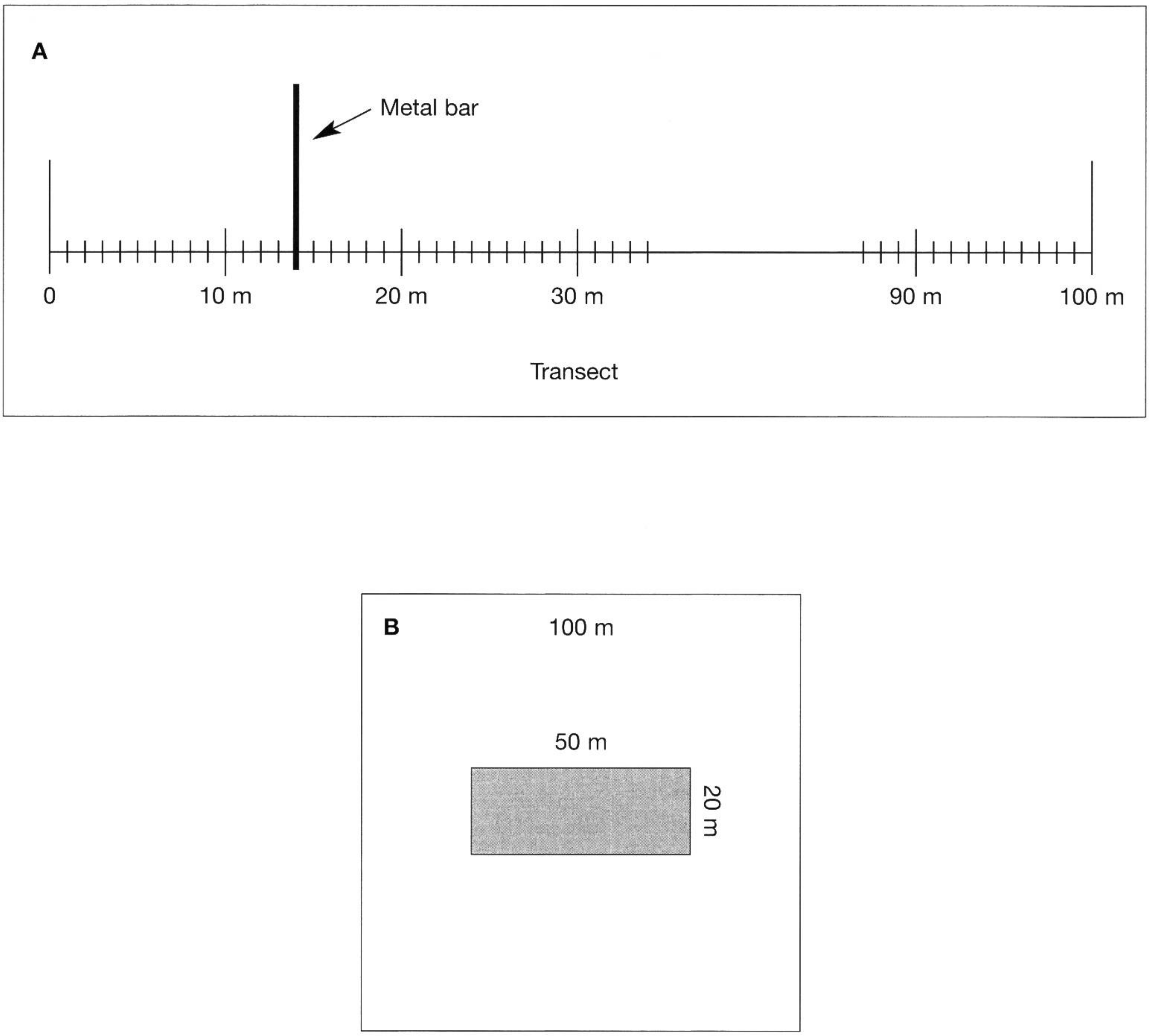

Fig. 2. – **A.** Method of linear relevé along a transect. **B.** Relevé surface of (grey rectangle) in the 1 ha plot.

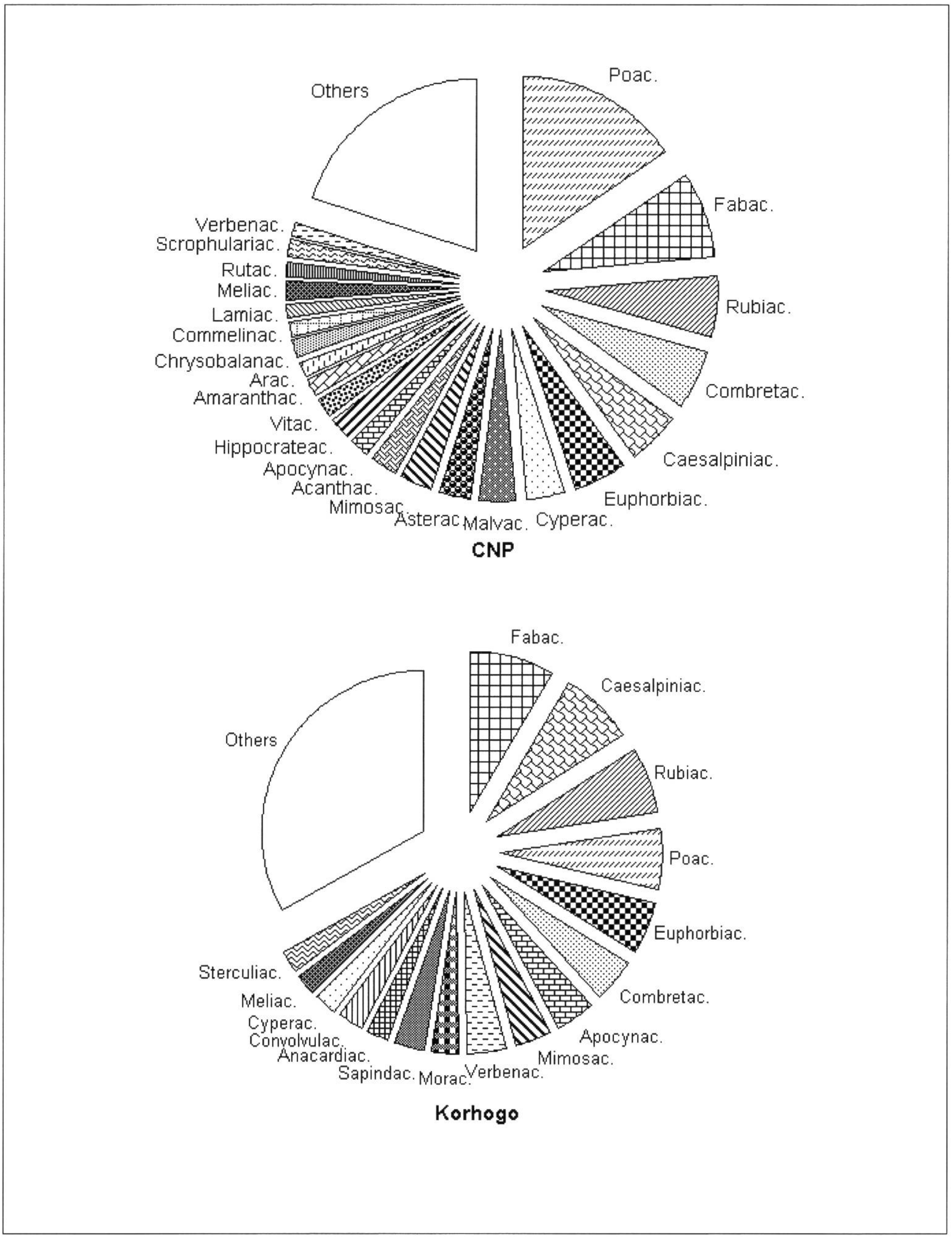

Fig. 3. – Spectra of the dominant families in the CNP and Korhogo regions.

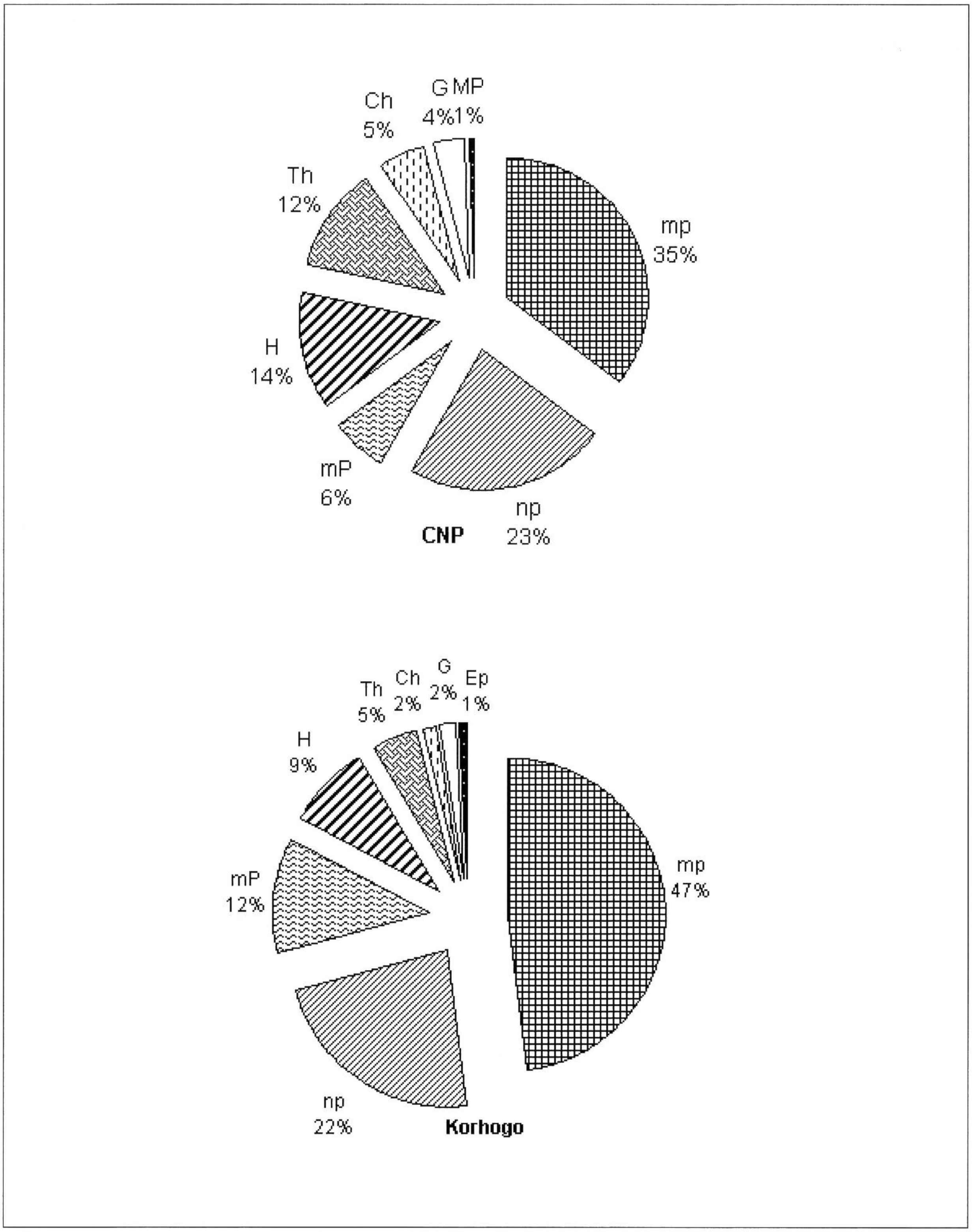

Fig. 4. – Life form spectra of the flora in the CNP and Korhogo regions; **np:** nanophanerophytes; **mp:** microphanerophytes; **mP:** mesophanerophytes; **MP:** megaphanerophytes; **Th:** therophytes; **Ch:** chamaephytes; **Ep:** epiphytes; **G:** geophytes; **H:** hemicryptophytes.

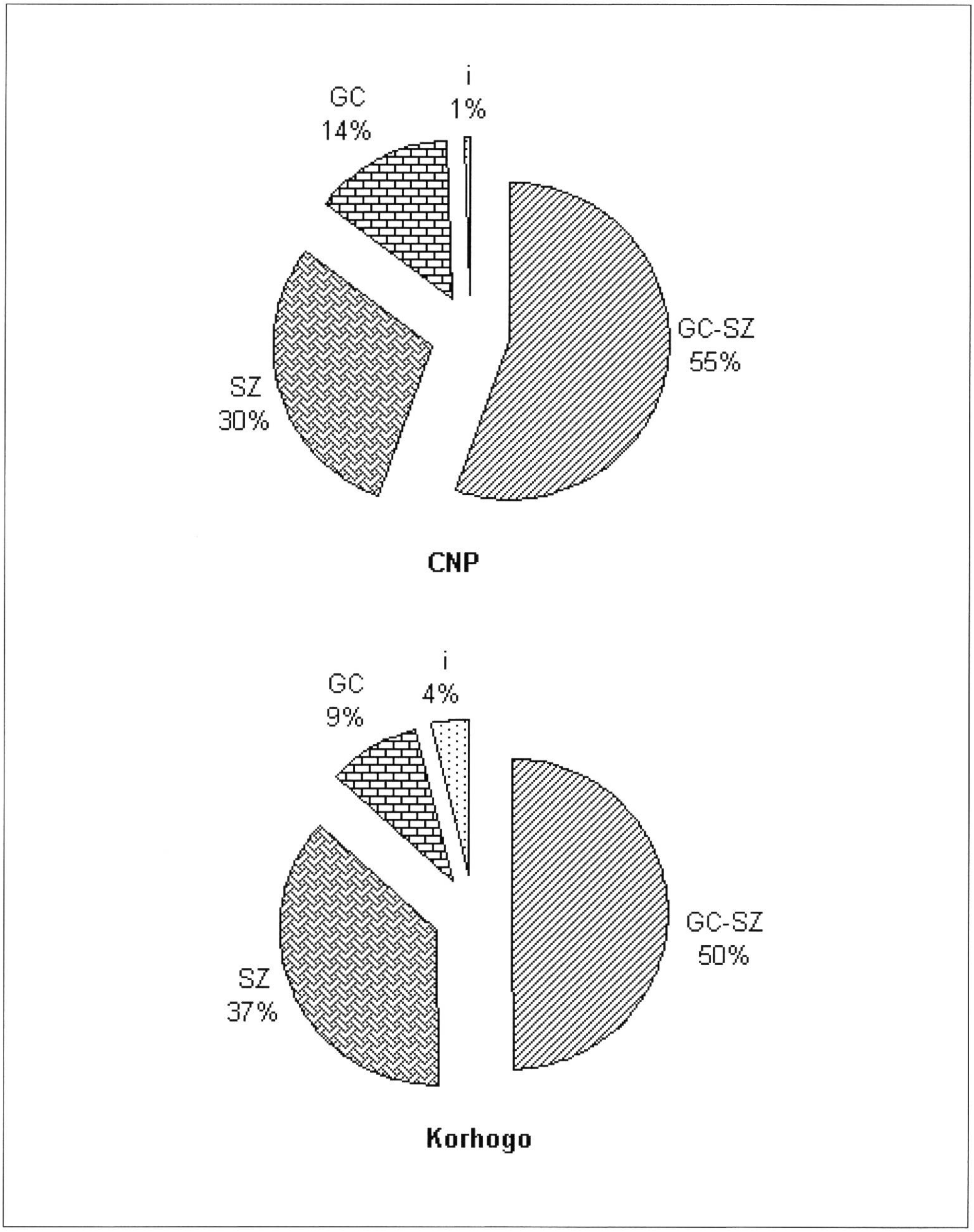

Fig. 5. – Chorological distribution spectra of species in the CNP and Korhogo regions; **GC:** Guineo-Congolian taxa; **SZ:** Soudano-Zambesian taxa; **GC-SZ:** transition taxa; **i:** introduced taxa.

Table 1. – Means and standard deviations of rainfall (mm) from 1971 to 1996 in Dabakala (nearest to Southern Comoé National Park) and the Korhogo climate stations (data source: FAO Agrometeorology Group, 2000).

Months	Dabakala		Korhogo	
January	2	±6	8	±15
February	14	±18	13	±17
March	59	±55	57	±53
April	110	±53	91	±40
May	110	±55	130	±64
June	113	±63	145	±47
July	95	±66	196	±71
August	136	±101	276	±81
September	166	±94	240	±53
October	94	±67	132	±104
November	11	±17	31	±33
December	12	±18	9	±10
Year	919	±263	1235	±194

Table 2. – Mean vegetation cover in different strata of the protected and exploited savanna plots [in %].

Study regions	**Vegetation type**	***n***	**0-2 m**	**2-5 m**	**5-10 m**	**10-20 m**
Comoé National Park	Savanna woodland	*3*	83±6	73±9	33±6	17±20
	Tree savanna	*4*	75±10	20±14	28±13	18±13
	Shrub savanna	*4*	75±10	43±26	30±22	13±19
	Grass savanna	*3*	70±10	8±3	5±9	0
Korhogo area	Protected tree savanna	*1*	75	30	5	0
	Exploited shrub savanna	*3*	73±9	3±3	0	0
	Exploited grass savanna	*1*	65	2	5	2

Table 3. – Medians of density, basal area, and biomass in the CNP (protected area) and Korhogo (exploited area) (in brackets: values obtained without considering the one or two largest tree individuals in each plot).

	Grass savanna		Shrub savanna		Tree savanna		Savanna woodland	
Site	CNP (n=3)	Korhogo (n=1) exploited	CNP (n=4)	Korhogo (n=3) exploited	CNP (n=4)	Korhogo (n=1) protected	CNP (n=3)	Korhogo
Density (indiv./ha)	50	75 (60)	530	760	360 (345)	1595	660 (610)	–
Basal area (m^2/ha)	0.2	1.1 (0.4)	4.2	0.8	9.7 (2.4)	4.7	8.9 (5.4)	–
Woody biomass (t/ha)	0.5	3.2 (1.2)	12.8	1.1	43.1 (4.8)	8.8	27.3 (11.4)	–

Appendix 1. – Species observed in the CNP and Korhogo areas. **x:** presence; **np:** nanophanerophyte; **mp:** microphanerophyte; **mP:** mesophanerophyte; **MP:** megaphanerophyte; **Th:** therophyte; **Ch:** chamaephyte; **Ep:** epiphyte; **G:** geophyte; **H:** hemicryptophyte; **L:** liana; **GC:** Guineo-Congolian taxa; **SZ:** Soudano-Zambesian taxa; **GC-SZ:** transition taxa; **i:** introduced taxa.

Family	Species	Life form	Chorology	CNP	Korhogo
Acanthaceae	*Asystasia gangetica* (L.) T. Anderson	np	GC-SZ	x	–
	Blepharis maderaspatensis (L.) Roth	np	GC-SZ	x	x
	Justicia flava (Vahl) Vahl	np	GC	x	–
	Monechma ciliatum (Jacq.) Milne-Redh.	np	GC-SZ	x	–
	Phaulopsis falcisepala C. B. Clarke	np	GC-SZ	x	–
Agavaceae	*Sanseviera trifasciata* Prain	*	*	x	–
Amaranthaceae	*Cyathula prostrata* (L.) Blume	Ch	GC-SZ	x	–
	Gomphrena celosioides Mart.	Ch	GC-SZ	x	–
	Pandiaka heudelotii (Moq.) Hiern	Th	GC-SZ	x	–
Amaryllidaceae	*Haemanthus multiflorus* Martyn	G	GC-SZ	x	–
Anacardiaceae	*Anacardium occidentale* L.	mp	i	–	x
	Lannea acida A. Rich.	mp	GC-SZ	x	x
	Lannea nigritana (Scott-Elliot) Keay	mp	GC-SZ	x	–
	Mangifera indica L.	mP	i	–	x
Annonaceae	*Annona senegalensis* Pers.	np	SZ	x	x
	Uvaria chamae P. Beauv.	Lmp	GC-SZ	x	x
Apocynaceae	*Carissa edulis* Vahl	np	GC	x	x
	Holarrhena floribunda (G. Don) T. Durand & Schinz	mP	GC-SZ	x	–
	Landolphia calabarica (Staft) Bruce	LmP	GC	–	x
	Landolphia owariensis P. Beauv.	LmP	GC	x	x
	Saba comorensis (Boj.) Pichon	Lmp	GC-SZ	x	x
	Saba senegalensis (A. DC.) Pichon	Lmp	SZ	–	x
Araceae	*Anchomanes difformis* (Blume) Engl.	G	GC	x	–
	Anchomanes welwitschii Rendle	G	SZ	x	x
	Stylochiton hypogaeus Lepr.	G	SZ	x	–
Asclepiadaceae	*Leptadenia hastata* (Pers.) Decne.	LmP	SZ	–	x
	Mondia whitei (Hook. f.) Skeels	*	*	x	–
	Telosma africanum (N. E. Br.) Colwille	Lmp	GC	–	x
Asteraceae	*Aspilia africana* (Pers.) C. D. Adams	np	GC	–	x
	Aspilia bussei O. Hoffm. & Muschl.	np	GC-SZ	x	–
	Laggera gracilis (O. Hoffm. & Muschl.) C. D. Adams	np	SZ	x	–
	Synedrella nodiflora Gaertn.	Th	GC	x	–
	Vernonia guineensis Benth.	H	SZ	x	–
	Vicoa leptoclada (Webb) Dandy	Th	GC-SZ	x	–
Bignoniaceae	*Stereospermum kunthianum* Cham.	mp	SZ	–	x
Bombacaceae	*Bombax costatum* Pellegr. & Vuillet	mp	SZ	–	x
	Ceiba pentandra (L.) Gaertn.	MP	GC-SZ	x	x
Boraginaceae	*Coldenia procumbens* L.	*	*	–	x
	Cordia myxa L.	mp	SZ	–	x

Family	Species	Life form	Chorology	CNP	Korhogo
Caesalpiniaceae	*Anthonotha crassifolia* (Baill.) J. Léonard	mp	GC-SZ	–	x
	Anthonotha macrophylla P. Beauv.	mp	GC	–	x
	Burkea africana Hook.	mp	SZ	x	–
	Cassia absus L.	np	GC-SZ	x	–
	Cassia mimosoides L.	np	GC-SZ	x	x
	Cassia sieberiana DC.	mp	GC-SZ	x	x
	Daniellia oliveri (Rolfe) Hutch. & Dalziel	mP	SZ	x	x
	Detarium microcarpum Guill. & Perr.	mp	SZ	x	x
	Dialium guineense Willd.	mP	GC	x	–
	Isoberlinia doka Craib & Stapf	mp	SZ	x	x
	Bauhinia thonningii (Schumach.) Milne-Redh.	mp	GC-SZ	x	x
	Swartzia madagascariensis Desv.	mp	SZ	–	x
	Tamarindus indica L.	mp	GC-SZ	x	x
Capparaceae	*Ritchiea reflexa* (Thonn.) Gilg & Ben.	np	SZ	–	x
Celastraceae	*Maytenus senegalensis* (Lam.) Exell	mp	SZ	x	x
Chrysobalanaceae	*Maranthes polyandra* (Benth.) Prance	mp	SZ	x	–
	Parinari congensis F. Didr.	mP	GC-SZ	x	x
	Parinari curatellifolia Benth.	mp	SZ	x	x
Cochlospermaceae	*Cochlospermum planchonii* Hook. f.	np	SZ	x	x
Combretaceae	*Anogeissus leiocarpus* (DC.) Guill. & Perr.	mp	SZ	x	x
	Combretum alatum Craib	*	*	x	–
	Combretum blepharopetalum Wickens	Lmp	GC	x	–
	Combretum dolichopetalum Engl. & Diels	mp	GC	x	–
	Combretum hispidum M. A. Lawson	Lmp	GC	x	–
	Combretum molle G. Don	mp	SZ	–	x
	Combretum nigricans Guill. & Perr.	mp	SZ	x	–
	Combretum smeathmannii G. Don	Lmp	GC	x	–
	Guiera senegalensis J. F. Gmel.	np	SZ	–	x
	Terminalia avicennioides Guill. & Perr.	mp	SZ	x	x
	Terminalia glaucescens Benth.	mp	SZ	x	–
	Terminalia laxiflora Engl. & Diels	mp	SZ	–	x
	Terminalia macroptera Guill. & Perr.	mp	SZ	x	x
	Terminalia mollis M. A. Lawson	mp	SZ	x	–
Commelinaceae	*Aneilema sinicum* Ker-Gawl.	*	*	x	–
	Commelina bracteosa Hassk.	Ch	SZ	x	–
	Murdannia simplex (Vahl) Brenan	Ch	SZ	x	–
Convolvulaceae	*Evolvulus alsinoides* (L.) L.	Ch	GC-SZ	–	x
	Ipomoea asarifolia (Desr.) Roem. & Schult.	Lmp	GC-SZ	–	x
	Ipomoea blepharophylla Hallier f.	H	SZ	–	x
Cucurbitaceae	*Melothria capillacea* (Schumach.) Cogn.	Lnp	GC	x	–
Cyperaceae	*Bulbostylis barbata* (Rottb.) C. B. Clarke	Th	GC-SZ	–	x
	Cyperus alternifolius L.	G	i	x	–
	Cyperus haspan L.	Th	GC-SZ	x	–

Family	Species	Life form	Chorology	CNP	Korhogo
Cyperaceae	*Cyperus sphacelatus* Rottb.	H	GC-SZ	–	x
	Eleocharis complanata Boeck.	Th	GC-SZ	x	–
	Fimbristylis dichotoma (L.) Vahl	H	GC-SZ	–	x
	Fimbristylis ferruginea (L.) Vahl	H	SZ	x	–
	Mariscus alternifolius Vahl	H	GC-SZ	x	–
	Mariscus cylindristachyus Steud.	H	GC-SZ	x	–
	Schoenoplectus senegalensis (Steud.) J. Raynal	Th	SZ	x	–
Dichapetalaceae	*Tapura fischeri* Engl.	mp	GC	x	–
Dioscoreaceae	*Dioscorea preussii* Pax	G	GC	x	–
	Dioscorea togoensis Knuth	G	GC-SZ	–	x
Dipterocarpaceae	*Monotes kerstingii* Gilg	mp	SZ	x	–
Ebenaceae	*Diospyros abyssinica* (Hiern) F. White	mp	GC-SZ	x	–
	Diospyros mespiliformis A. DC.	mp	GC-SZ	x	x
Euphorbiaceae	*Antidesma venosum* Tul.	mp	GC-SZ	–	x
	Bridelia ferruginea Benth.	mp	GC-SZ	x	–
	Croton hirtus L'Hér.	np	GC	x	x
	Euphorbia convolvuloides Benth.	Ch	SZ	x	–
	Hymenocardia acida Tul.	mp	GC-SZ	x	x
	Mallotus oppositifolius (Geisel.) Müll. Arg.	mp	GC-SZ	x	–
	Phyllanthus amarus Schumach. & Thonn.	np	GC	x	–
	Phyllanthus beillei Hutch.	np	GC-SZ	–	x
	Phyllanthus discoideus (Baill.) Müll. Arg.	mp	GC-SZ	x	x
	Phyllanthus reticulatus Poir.	np	GC-SZ	–	x
	Sapium ellipticum (Hochst.) Pax	mp	GC-SZ	x	–
	Tragia volubilis L.	Lnp	GC	x	–
	Uapaca togoensis Pax	mP	GC-SZ	x	x
Fabaceae	*Abrus precatorius* L.	Lmp	GC-SZ	x	–
	Crotalaria calycina Schrank	Th	GC-SZ	x	–
	Crotalaria vogelii Benth.	np	SZ	x	–
	Desmodium gangeticum (L.) DC.	np	GC-SZ	x	–
	Desmodium ramosissimum G. Don	np	GC-SZ	x	–
	Desmodium tortuosum (Sw.) DC.	np	GC-SZ	x	–
	Desmodium velutinum (Willd.) DC.	np	GC-SZ	x	–
	Eriosema cajanoides Hook. f.	*	*	–	x
	Eriosema griseum Baker	H	SZ	x	–
	Eriosema molle Milne-Redh.	np	GC	–	x
	Erythrina senegalensis DC.	mp	GC-SZ	–	x
	Indigofera dendroides Jacq.	np	GC-SZ	x	–
	Indigofera pilosa Poir.	np	SZ	–	x
	Indigofera stenophylla Guill. & Perr.	np	SZ	–	x
	Mucuna pruriens (L.) DC.	Th	GC-SZ	–	x
	Pericopsis laxiflora (Benth.) Meeuwen	mp	SZ	x	x
	Pterocarpus erinaceus Poir.	mp	SZ	x	x

Family	Species	Life form	Chorology	CNP	Korhogo
Fabaceae	*Rhynchosia buettneri* Harms	Lmp	GC-SZ	–	x
	Stylosanthes fruticosa (Retz.) Alston	np	GC-SZ	–	x
	Tephrosia pedicellata Baker	Ch	GC-SZ	x	x
	Uraria picta (Jacq.) DC.	np	GC-SZ	x	–
	Vigna filicaulis Hepper	Lnp	GC-SZ	x	–
	Vigna pubigera Baker	Lmp	GC-SZ	x	–
	Zornia glochidiata DC.	Th	GC-SZ	x	–
Flacourtiaceae	*Flacourtia flavescens* Willd.	mp	SZ	x	x
	Oncoba spinosa Forssk.	mp	GC-SZ	x	–
Hippocrateaceae	*Campylostemon warneckeanum* Fritsch	LmP	GC	x	–
	Salacia erecta (G. Don) Walpers	Lmp	GC	x	–
	Salacia howesii Hutch. & Moss	Lmp	GC	x	–
	Salacia pallescens Oliv.	np	GC	x	–
Hypericaceae	*Psorospermum febrifugum* Spach	mp	GC-SZ	x	x
Hypoxidaceae	*Curculigo pilosa* (Schumach. & Thonn.) Engl.	H	SZ	–	x
Lamiaceae	*Hoslundia opposita* Vahl	np	GC-SZ	x	x
	Hyptis suaveolens Poit.	np	GC-SZ	–	x
	Solenostemon monostachyus (P. Beauv.) Briq.	*	*	x	–
	Solenostemon repens (Gürke) Morton	Ch	GC	x	–
Liliaceae	*Asparagus africanus* Lam.	np	SZ	x	–
Loganiaceae	*Strychnos innocua* Delile	mp	SZ	–	x
	Strychnos spinosa Lam.	mp	SZ	x	x
Lauraceae	*Cassytha filiformis* L.	Lnp	GC-SZ	–	x
Loranthaceae	*Tapinanthus dodoneifolius* (DC.) Danser	Ep	GC-SZ	–	x
Malvaceae	*Hibiscus asper* Hook. f.	np	GC-SZ	x	–
	Hibiscus congestiflorus Hochr.	np	GC-SZ	x	–
	Sida alba L.	np	GC-SZ	x	–
	Sida cordifolia L.	np	GC-SZ	–	x
	Sida linifolia Cav.	np	GC-SZ	x	–
	Sida rhombifolia L.	np	GC-SZ	x	–
	Sida urens L.	np	GC-SZ	x	–
	Wissadula amplissima (L.) R. E. Fr.	np	GC-SZ	x	–
Meliaceae	*Azadirachta indica* A. Juss.	mp	i	–	x
	Khaya senegalensis (Desv.) A. Juss.	mP	SZ	x	x
	Pseudocedrela kotschyi (Schweinf.) Harms	mp	SZ	x	–
	Trichilia emetica Vahl	mp	SZ	x	x
Mimosaceae	*Acacia nilotica* subsp. *tomentosa* (Benth.) Brenan	*	*	–	x
	Acacia seyal Delile	*	*	x	–
	Acacia sieberiana DC.	mp	SZ	–	x
	Afzelia africana Pers.	mp	*	x	x
	Albizia glaberrima (Schumach. & Thonn.) Benth. var. *glaberrima*	mP	GC	x	–
	Albizia zygia (DC.) J. F. Macbr.	mP	GC-SZ	x (PNC)	x

Family	Species	Life form	Chorology	CNP	Korhogo
Mimosaceae	*Dichrostachys cinerea* (L.) Wight & Arn.	mp	GC-SZ	x	x
	Parkia biglobosa (Jacq.) G. Don	mp	SZ	x	x
Moraceae	*Antiaris toxicaria* Lesch.	mP	GC-SZ	x	x
	Ficus gnaphalocarpa (Miq.) A. Rich.	mp	SZ	–	x
	Ficus sur Forssk.	mp	GC-SZ	x	x
	Ficus vallis-choudae Delile	mp	SZ	–	x
Myrtaceae	*Syzygium guineense* (Willd.) DC.	mp	GC-SZ	x	x
Ochnaceae	*Lophira lanceolata* Keay	mP	SZ	x	–
	Ochna schweinfurthiana F. Hoffm.	np	SZ	–	x
Olacaceae	*Olax subscorpioidea* Oliv.	*	*	–	x
	Ximenia americana L.	mp	GC-SZ	x	–
Opiliaceae	*Opilia amentacea* Roxb.	LmP	SZ	x	x
Oxalidaceae	*Biophytum petersianum* Klotzsch	Th	GC-SZ	x	–
Passifloraceae	*Passiflora foetida* L.	Lnp	GC	–	x
Poaceae	*Acroceras zizanioides* (Kunth) Dandy	np	GC-SZ	x	–
	Andropogon chinensis (Nees) Meer.	H	GC-SZ	x	–
	Andropogon fastigiatus Sw.	Th	GC-SZ	x	–
	Andropogon gayanus Kunth	H	GC-SZ	x	x
	Andropogon perligulatus Stapf	H	GC-SZ	–	x
	Andropogon schirensis A. Rich.	H	GC-SZ	x	x
	Aristida kerstingii Pilg.	Th	SZ	x	–
	Brachiaria jubata (Fig. & De Not.) Stapf	H	GC-SZ	x	–
	Ctenium canescens Benth.	H	SZ	x	–
	Ctenium elegans Kunth	Th	SZ	–	x
	Digitaria ciliaris (Retz.) Koeler	Th	GC-SZ	x	–
	Digitaria longiflora (Retz.) Pers.	Th	GC-SZ	x	–
	Elymandra androphila (Stapf) Stapf	H	GC-SZ	x	–
	Elymandra grallata (Stapf) Clayton	H	SZ	x	–
	Eragrostis lingulata Clayton	*	*	x	–
	Eragrostis turgida (Schumach.) De Wild.	Th	GC-SZ	x	–
	Euclasta condylotricha (Steud.) Stapf	Th	SZ	x	–
	Hackelochloa granularis (L.) Kuntze	Th	GC-SZ	x	–
	Hyparrhenia diplandra (Hack.) Stapf	H	GC-SZ	x	–
	Hyparrhenia involucrata Stapf	Th	SZ	x	–
	Hyparrhenia subplumosa Stapf	H	GC-SZ	x	–
	Hyparrhenia welwitschii (Rendle) Stapf	H	GC-SZ	x	–
	Loudetia annua (Stapf) C. E. Hubb.	Th	GC-SZ	x	–
	Loudetia kagerensis (K. Schum.) Hutch.	H	GC-SZ	x	–
	Loudetia simplex (Nees) Hubbard	H	GC-SZ	x	–
	Microchloa indica (L. f.) P. Beauv.	Th	GC-SZ	x	–
	Panicum maximum Jacq.	H	GC	x	–
	Panicum phragmitoides Stapf	H	GC-SZ	x	–
	Paspalum scrobiculatum L.	H	GC-SZ	–	x

Family	Species	Life form	Chorology	CNP	Korhogo
Poaceae	*Pennisetum polystachion* (L.) Schult.	Th	GC-SZ	x	x
	Pennisetum unisetum (Nees) Benth.	H	GC-SZ	x	–
	Schizachyrium sanguineum (Retz.) Alston	H	GC-SZ	x	–
	Setaria barbata (Lam.) Kunth	Th	GC-SZ	x	–
	Sporobolus pyramidalis P. Beauv.	H	GC-SZ	x	x
	Vetiveria nigritana (Benth.) Stapf	H	GC-SZ	–	x
Polygalaceae	*Polygala arvensis* Willd.	*	*	x	–
	Securidaca longepedunculata Fresen.	mp	SZ	x	x
	Polygonum lanigerum R. Br.	np	GC-SZ	–	x
Rubiaceae	*Borreria filifolia* (Schumach. & Thonn.) K. Schum.	Th	GC-SZ	x	–
	Borreria octodon Hepper	np	GC-SZ	x	–
	Canthium pobeguinii Hutchinson & Daziel	mp	GC	–	x
	Crossopteryx febrifuga (G. Don) Benth.	mp	GC-SZ	x	–
	Fadogia agrestis Hiern	np	SZ	x	–
	Gardenia aqualla Stapf & Hutch.	np	SZ	x	–
	Gardenia erubescens Stapf & Hutch.	np	SZ	–	x
	Gardenia ternifolia Schumach. & Thonn.	np	SZ	x	x
	Keetia venosa (Oliv.) Bridson	Lmp	GC-SZ	x	–
	Macrosphyra longistyla (DC.) Hiern	LmP	GC-SZ	–	x
	Mitragyna inermis (Willd.) Kuntze	mp	SZ	x	–
	Oxyanthus racemosus (Schumach. & Thonn.) Keay	np	GC-SZ	x	–
	Pavetta crassipes K. Schum.	mp	SZ	–	x
	Psydrax parviflora (Afzel.) Bridson	mp	GC	x	–
	Sarcocephalus latifolius (Smith) Bruce	Lmp	GC-SZ	x	x
	Spermacoce mauritiana Gideon	*	*	–	x
	Spermacoce ocymoides L.	Ch	GC	x	–
	Spermacoce radiata (DC.) Hiern	Th	GC-SZ	–	x
	Spermacoce ruelliae DC.	Th	GC-SZ	–	x
Rutaceae	*Afraegle paniculata* (Schumach.) Engl.	mp	GC-SZ	x	–
	Clausena anisata (Willd.) Benth.	np	GC-SZ	x	x
	Zanthoxylum zanthoxyloides (Lam.) Zepern. & Timler	mp	GC-SZ	x	x
Sapindaceae	*Allophylus africanus* f. *chrysothrix* Radlk.	mp	GC-SZ	x	x
	Allophylus spicatus (Poir.) Radlk.	mp	SZ	x	x
	Blighia sapida K. D. Koenig	mP	GC-SZ	–	x
	Deinbollia pinnata Schumach. & Thonn.	np	GC	–	x
Sapotaceae	*Manilkara multinervis* (Baker) Dubard	mp	GC-SZ	x	x
	Vitellaria paradoxa C. F. Gaertn.	mp	SZ	x	x
Scrophulariaceae	*Scoparia dulcis* L.	np	GC-SZ	x	–
	Striga gesnerioides (Willd.) Vatke	Ch	SZ	x	–
	Striga hermonthica (Delile) Benth.	Ch	SZ	x	–
Solanaceae	*Schwenckia americana* L.	np	GC-SZ	x	–
Sphenocleaceae	*Sphenoclea zeylanica* Gaertn.	Th	GC-SZ	x	–
Sterculiaceae	*Cola cordifolia* (Cav.) R. Br.	mP	SZ	–	x

Family	Species	Life form	Chorology	CNP	Korhogo
Sterculiaceae	*Cola millenii* K. Schum.	mp	GC	x	–
	Sterculia setigera Delile	mp	SZ	–	x
	Waltheria indica L.	np	GC-SZ	–	x
Taccaceae	*Tacca leontopetaloides* (L.) Kuntze	G	SZ	x	–
Tiliaceae	*Grewia mollis* Juss.	mp	GC	x	–
Ulmaceae	*Trema guineensis* Schumach. & Thonn.	mp	GC-SZ	–	x
Verbenaceae	*Clerodendrum alatum* Gürke	np	SZ	x	–
	Clerodendrum capitatum (Willd.) Schumach. & Thonn.	np	GC-SZ	–	x
	Gmelina arborea Roxb.	mp	i	–	x
	Stachytarpheta angustifolia (Mill.) Vahl	np	GC-SZ	–	x
	Tectona grandis L. f.	mP	i	–	x
	Vitex doniana Sweet	mp	GC-SZ	x	x
	Vitex simplicifolia Oliv.	mp	SZ	x	–
Vitaceae	*Cissus doeringii* Gilg & M. Brandt	H	GC-SZ	x	x
	Cissus flavicans (Baker) Desc.	H	GC-SZ	x	–
	Cissus populnea Guill. & Perr.	Lmp	GC-SZ	x	x
	Cissus producta Afzel.	Lmp	GC	x	–
Zingiberaceae	*Aframomum latifolium* K. Schum.	*	*	x	–
	Siphonochilus aethiopicus (Schweinf.) B. L. Burtt	H	SZ	x	–