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PLANT DIVERSITY, VEGETATION STRUCTURE AND RELATIONSHIP BETWEEN PLANT COMMUNITIES AND ENVIRONMENTAL VARIABLES IN THE AFROMONTANE FORESTS OF ETHIOPIA

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ABSTRACT: Diversity patterns of vascular plant species were studied along geographical gradients in the Afromontane regions of Ethiopia. Vegetation data were sampled from five moist evergreen Afromontane forest fragments, namely Harenna (southeast), Bonga, Maji, Berhane-Kontir and Yayu (southwest). In each forest, quadrats of 20x20 m were laid along transects to collect vegetation data. The patterns of plant diversity were evaluated on the basis of species richness as the total number of species at each site and species change between and within sites and in relation to vegetation structure. Floristic analyses of five Afromontane forests altogether revealed 118 families and 653 vascular plant species; about 5% of the species were endemic. Species richness and densities vary considerably between the forest sites. The highest beta and gamma diversities were recorded in the Berhane-Kontir forest and the lowest in Bonga. The studied Afromontane forests were floristically different but the common feature of the geographically separated forests is the occurrences of wild coffee populations. Ordination of the study quadrats of the forests forms five groups based on the species composition. Moist evergreen Afromontane forests support a high density of woody plants, which, however, differ between sites. The Ethiopian moist evergreen Afromontane forests are highly threatened due to anthropogenic factors and, thus, need immediate conservation measures. It is recommended that conservation strategies should focus on multiple-sites conservation networking in order to include a range of forests in the conservation system.

Key words/phrases: Alpha diversity, beta diversity, biodiversity conservation, floristic similarity, gamma diversity

INTRODUCTION

Forest landscapes in Ethiopia are currently threatened due to habitat conversion, loss, and fragmentation that occurred over the past many years (Logan, 1946; Bonnefill and Buchet, 1986; Darbyshire *et al*., 2003). Today, moist evergreen Afromontane forest vegetation represents the major forest fragments remaining in the country. Moist evergreen Afromontane (hereafter Afro-montane) forest is one of the forest vegetation types that occur mostly on the wetter slopes of the higher mountains of the country (White, 1983; Friis, 1992; Friis and Sebsebe Demissew, 2001; Friis *et al*., 2010). The majority of these moist evergreen Afromontane forest fragments are important for the conservation of highland forest bird species (EWNHS, 1996; Tadesse Woldemariam, 2003), plant diversity (Tadesse Woldemariam 2003; Feyera Senbeta *et al*., 2005; Feyera Senbeta 2006) and wild populations of *Coffea arabica* (Tadesse Woldemraim *et al*., 2002; Feyera Senbeta and Denich, 2006). Despite all their importance, however, the Ethiopian Afromontane forest fragments are continuously shrinking owing to deforestation (Reusing, 2000; Tadesse Woldemriam *et al*., 2002; Feyera Senbeta *et al*., 2005; Dereje Tadesse *et al*., 2008). To minimize loss of these forest fragments, understanding the ecological and anthropogenic factors involved in the process are highly important.

In particular, studies of plant species diversity have been very important issues for prioritizing conservation activities (Lovett *et al*., 2000; Myers *et al*., 2000). Studying species richness patterns at different scales is very important both for ecological explanations and for effective conser-vation design. In Ethiopia, studies on plant diversity are inadequate, and this is, especially, true for the moist evergreen Afromontane forests. Previous works (*e.g.*, Friis *et al*., 1982; Friis, 1992; Mesfin Tadesse and Lisanework Nigatu, 1996; Tadesse Woldemariam, 2003) have documented a very limited extent of species diversity across the moist evergreen Afromontane forest region. Similarly, studies about the relationship between plant communities and environmental variables along geographical gradients are also limited in moist evergreen Afromontane forests of Ethiopia (Tadesse Woldemariam, 2003; Feyera Senbeta, 2006). Given this lack of information, studies that provide plant diversity patterns and vegetation structure in the moist evergreen Afromontane forest fragments have become one of the most important issues.

In the present study, a comparative analysis of the diversity of vascular plant species, vegetation structure and relationship between plant communities and environmental variables was carried out across five Afromontane forests (namely, Berhane-Konitr, Bonga, Harenna, Maji and Yayu) in Ethiopia. The specific objectives of the study were to: (i) assess the magnitude of species richness and diversity of Afromontane forests with wide geographical area coverage (alpha and gamma diversity); (ii) examine the patterns of species change (turnover) within and between geographically separated Afromontane forests (beta diversity); (iii) describe the relationship between plant communities and environmental variables along geographical gradients; and (iv) recommend conservation strategies.

MATERIALS AND METHODS

Description of the study area

The physiographic features of Ethiopia are characterised by the formation of the Eastern and Western highland plateaus, which are separated by the Ethiopian Rift Valley system. The present study was conducted in five moist evergreen Afromontane forests of Ethiopia, namely Berhane-Kontir, Bonga, Harenna, Maji and Yayu forests (Fig. 1 and Table 1). Except for the Harenna forest, which is located in the Eastern highland plateau, all other forests are located on the Western highland plateau.

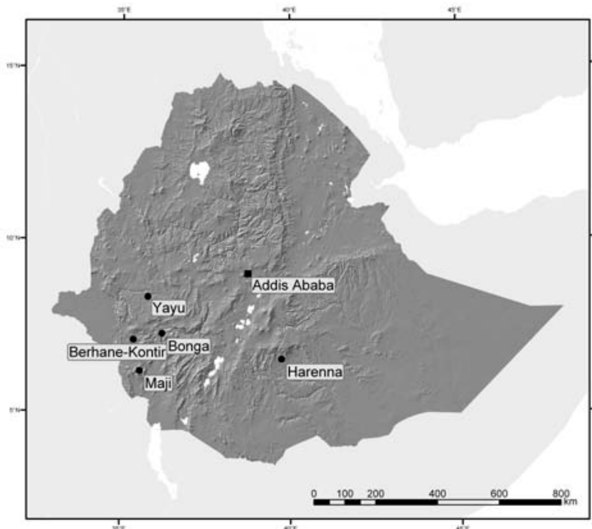

Figure 1. Map of Ethiopia showing the location of the study areas.

The climatic resources of Ethiopia are explained by the variations in spatial and temporal distribution of rainfall, temperature and potential evapotranspiration (Eklundh, 1996). For example, there is variability in the total amount as well as the time of arrival of rainfall over the study areas. The mean annual rainfall is high in the area of southwest forests and decreases towards the southeast (Table 1). The Berhane-Kontir, Bonga, Maji and Yayu forests receive unimodal rainfall between June and October, while Harenna receives bimodal rainfall from February to April and from September to November. Temperatures generally vary little over the year, mainly controlled by altitude, although the maximum and minimum temperatures can vary somewhat with geographic location (Eklundh, 1996), and range from 10 (minimum) to 29°C (maximum) across the different study sites.

Table 1. Location and characteristic of the studied Afromontane forests in Ethiopia.

Sites	Code	Elevation (m)	Area (ha)	Lat. (N)	Long. (E)	TRF[1] (mm)	Tmin (^{0}C)	Tmax (^{0}C)	No. quadrats
Bonga	BO	1600–2300	5000	7^0 08′	$35^0$53′	1718 (49)	12	26	28
Berhane-Kontir	BK	940–1800	10000	7^0	35^0	2200(30)	15	29	37
Maji	MA	1600–1750	2000	6^0	36^0	1200 (23)	14	26	10
Yayu	YA	1200–2150	10000	8^0 05′	35^0 06′	1586(20)	13	28	48
Harenna	HA	1400–2000	15000	6^0	40^0	1000(20)	10	28	24

[1] **TRF-total annual rainfall and figure in the bracket shows years of meteorological observation); Tmin- Minimum Temperature; Tmax-Maximum temperature; Source: NMA (2002) for climatic data**.

The major dominant soil type in the moist evergreen Afromontane forest region is Dystric Nitosols (Murphy, 1968; Tafesse Asres, 1996). More often, Regosols, Cambisols, and Acrisols also commonly occur.

Afromontane forests contribute significantly to the economic and social welfare of the rural communities living in and around the forest, for examples as a source of timber and non-timber forest products. More importantly, regions with the moist evergreen Afromontane forests are known for their high population influx because of their high production potential and favourable environment for living, which further added pressure on the forest resources.

Methods

Vegetation surveys were carried out between May and June 2003 and from October 2003 to June 2004 in the Afromontane forests of Ethiopia. Quadrats of 20 x 20 m were laid down along transects in each forest. A total of 147 quadrats were distributed in the relatively undisturbed (i.e., absence of logging, coffee management, and other agricultural practices) parts of the forests (Table 1). However, the total number of sample plots for each forest was varied proportionally to the size of the forest. In each quadrat, all woody plants with diameter at breast height (dbh) $\geq$2 cm and height $\geq$0.5 m were identified, counted and recorded. Diameter at breast height, *i.e.,* 1.3m above ground and height was measured using diameter tape and hypsometer, respectively. In each quadrat, the presence of seedlings, saplings, epiphytes, herbs, grasses, sedges and ferns were also recorded. Relevant data for Yayu forest were obtained from the report of Tadesse Woldemariam (2003). Species occurring outside the quadrats were recorded to ensure complete floristic inventory. Plant identification was carried out both in the field and in the herbarium, and voucher specimens were collected, identified and deposited in the National Herbarium, Addis Ababa University. Additionally, the Royal Botanic Gardens at Kew, United Kingdom, was visited for specimen identification.

Nomenclature of plant taxa follows Edwards *et al*. (1995; 1997; 2000), Hedberg and Edwards (1989, 1995) and Hedberg *et al*. (2003; 2004; 2006; 2009).

Data analysis

The patterns of plant diversity at different scales were evaluated using the Shannon-Wiener (hereafter Shannon) diversity index and evenness, Fisher's α (the relationship between the number of species and abundance), beta (species change over a range of habitats or sites) and gamma (total number of species across study region) (Magurran, 1988). In particular, beta diversity was determined using the Whittaker (1972) and Wilson and Shmida (1984) methods. To calculate the different diversity indices, the software Biodiversity Pro (McAleece, 1997) was used. To determine floristic similarity between the five forests, Sørensen's similarity coefficient (SSC) was employed. Size-class distribution, density and basal area of the woody species were used for structural analyses. On the other hand, two-way correlation and linear regression were used to investigate the relationship between coffee abundance and species richness.

The patterns of species and quadrats distribution along the geographical gradients were examined using Detrended Correspondence Analysis (DCA). DCA was chosen because it met the criteria of (1) ecological interpretability, and (2) effective spreading out of the points according to sites (Hill and Gauch, 1980). The computer program CANOCO, Version 4.5 (ter Braak, 2003) was used for the analysis. Spatial relationships of both species and quadrats within a multi-dimensional ordination space were illustrated in relation to vectors representing statistically significant of environmental variables. For this analysis, four of studied forests, 100 species, three environmental variables (slope, altitude and canopy cover) and disturbance factor were used. Data set from Maji forest was incomplete and, hence, excluded from the analyses. Slope was estimated using clinometers whereas altitude estimated using pocket altimeter and Garmin GPS-72. Tree canopy cover was estimated visual. Disturbance scores were made on the basis of visible signs of coffee harvesting, honey production, grazing and tree cutting. The type and extent of disturbance were evaluated for each plot on ordinal scales from 0 to 3 (where 0 represents the absence of the influence and 3 the highest influence. Overall, the combined impact of these disturbances was rated higher than the individual effects.

RESULTS

Floristic composition

A total of 653 plant species, representing 486 genera and 118 families, were recorded, including species found outside the quadrats (Appendix 1). These included 16 pteridophytes, 2 gymnosperm, 100 angiosperm families as well as 50 pteridophyte, 601 angiosperm and 2 gymnosperm species in the five studied forests. The most species-rich family was Orchidaceae (with 20 genera and 39 species) followed by Rubiaceae (26 genera and 32 species), Fabaceae (21 genera and 31 species) and Asteraceae (17 genera and 30 species). The 10 and 20 species-rich families contributed 37 and 51% of the total species, respectively (Appendix 1). A comparison of taxa distribution for each site is indicated in Table 2. The highest and lowest number of families, genera and species were recorded from Berhan-Kontir and Maji forests, respectively (Table 2).

Table 2. Number of plant families, genera and species recorded in the studied Afromontane forests.

Characteristics	BK	*BO	HA	MA	YA	Total
No. of families	95	92	86	55	72	118
No. of genera	259	207	221	115	163	486
No. of species	374	285	289	146	217	651

*Abbreviations as in Table 1.

Despite a high similarity in family composition, the order of family dominance varied between the studied forests (Table 3). Of 118 total families recorded, 42 (36%) occurred in all five forests, 19 (16%) occurred in four forests, 21(18%) occurred in three forests, 12(10%) occurred in two forests and 24 (20%) occurred in only one forest (Appendix 1). Among the families recorded only in one forest, 10 were from Berhane-Kontir (*i.e.,* Balanophoraceae, Costaceae, Dilleniaceae, Hyacinthaceae, Marantaceae, Musaceae, Nyctaginaceae, Smilaceae, Thelypteridaceae and Violaceae), seven were from Bonga (Aquifoliaceae, Chenopodiaceae, Marattiaceae, Melastomataceae, Polygonaceae, Primulaceae and Vittariaceae), five were from Harenna (Basellaceae, Canellaceae, Cupressaceae, Erythroxylaceae and Scrophulariaceae), two were from Yayu (Cannaceae and Taccaceae) and none from Maji forest.

Of the total 653 species recorded, 46 (7%) occurred in the five forests, 48 (7%) in four forests, 84 (13%) in three forests, 167 (26%) in two forests and the largest proportion 308 (47%) species occurred only in one of the forests. Of those species recorded only from one forest, 120 species were from Berhane-Kontir, 88 species were from Harenna, 64 species were from Bonga, 29 species were from Yayu and 7 species were from Maji forest (Appendix 1). Of the total number of species recorded in the five forests, 31 are endemic species to Ethiopia.

The SSC of all the five forests ranged between 0.42 and 0.50. The highest and lowest floristic similarities were found between Harenna and Bonga (SSC = 0.50), and Yayu and Bonga/Harenna (0.42) forests, respectively.

Alpha, beta and gamma diversity

At the 400 m^2 quadrats level, species richness ranged between 37 (Maji) and 66 (Bonga) species, and the overall mean number of species/plot in the five forests was 49 (Table 3). On the other hand, the highest and lowest Fisher's α was recorded in Berhane-Kontir (24.4) and Yayu (9.9) forests, respectively. The Shannon diversity indices ranged between 1.54 and 3.17, with the highest and lowest values recorded from Bonga and Maji forests, respectively, while the highest and lowest Shannon evenness indices were obtained from Bonga and Maji forests, respectively.

Table 3. The top 10 species-richest families in the studied Afromontane forests of Ethiopia, and number of species (S) in decreasing order in each study forest.

All regions		Forest region/family				
Family	S	BO*	BK	YA	MA	HA
Orchidaceae	40	Fabacae	Orchidaceae	Euphorbiaceae	Rubiaceae	Fabacae
Rubiaceae	32	Asteraceae	Rubiaceae	Rubiaceae	Fabacae	Rubiaceae
Fabaceae	31	Orchidaceae	Euphorbiaceae	Orchidaceae	Euphorbiaceae	Orchidaceae
Asteraceae	30	Euphorbiaceae	Moraceae	Fabacae	Celastraceae	Euphorbiaceae
Euphorbiaceae	29	Aspleniaceae	Acanthaceae	Moraceae	Rutaceae	Asteraceae
Acanthaceae	25	Rubiaceae	Fabacae	Asteraceae	Aspleniaceae	Acanthaceae
Poaceae	24	Poaceae	Poaceae	Malvaceae	Sapindaceae	Celastraceae
Moraceae	19	Labiatae	Aspleniaceae	Acanthaceae	Moraceae	Rutaceae
Aspleniaceae	16	Celastraceae	Sapindaceae	Celastraceae	Asteraceae	Sapindaceae
Asclepiadaceae	15	Piperaceae	Amaranthaceae	Poaceae	Malvaceae	Aspleniaceae

Abbreviations as in Table 1.

The magnitude of beta diversity indicated the change in species richness between the adjacent transects along the same environmental gradient. The highest and lowest beta diversity indices were recorded in Berhane-Kontir and Bonga forests, respectively (Table 4). Overall, the two indices (*i.e.*, Whittaker (1972), and Wilson and Shmida (1984)) of beta diversity showed very close results for each site, and the values followed the order Berhane-Kontir > Harenna > Yayu > Maji > Bonga. The gamma diversity was the highest and lowest in the Berhane-Kontir and Maji forests, respectively (Table 4). On the other hand, a comparison of the studied forests shows that the Harenna forest had the highest number of endemic species followed by Berhane-Kontir and Bonga.

Distribution of wild coffee plants

Wild coffee populations exhibited patchy distribution at forest level. Patches of *Coffea arabica* occurred very close to each other (less than 20 m distance between the patches), frequently within an area, or there were large areas without *C. arabica* patches (greater than 100 m distance between the patches). The trends were similar in all studied forests except in the Yayu forest, where wild coffee plants were evenly and widely distributed throughout the forest (Table 5).

The distribution of wild coffee was affected by altitude, human interference and other environmental factors. For instance, the relationship between the abundance of wild coffee and altitude was non-linear. Along the gradient of altitude, the mean abundance of coffee plants per quadrat followed a bell-shaped type of distribution (Fig. 2). Coffee plants were found only between 940 and 2,050 m. The lowestand highest limits were recorded in Berhane-Kontir and Bonga forests, respectively. The highest densities of coffee plants were recorded between 1,300 and 1,600 m.

Interestingly, a significant negative relationship was observed between species richness and abundance of coffee plants ($P<0.0001$; $r^2 = 0.11$) in studied forests.

Vegetation structure

In all forests, a considerable number of woody plants (with ≥2 cm dbh) were found in the lower diameter classes (Table 6). For example, 69 and 45% of the individuals in Bonga and Harenna forests, respectively, were found in the dbh class between 2 and 5 cm. The number of individuals within the largest diameter class >47 cm ranged between 1 to 4 percent in Bonga and Harenna forest, respectively. The biggest diameter was recorded in the Harenna forest, i.e. 200 cm for *Podocarpus falcatus* followed by 187 cm for *Schefflera abyssinica* (Bonga), 150 cm for *Pouteria altissima* (Berhane-Kontir) and 143 cm for *Manilkara butugi* (Maji).

Table 4. Summary of the various diversity parameters calculated in the studied Afromontane forest areas

Characteristics	BO*	BK	HA	MA	YA*	Mean ±SE
Species richness per quadrat	66	45	46	37	30	44.8±6.04
Fisher's α	15.4	24.4	19.7	15.1	9.9	16.9±2.43
Shannon diversity	3.17	2.83	2.60	1.54	2.8	2.58±0.27
Shannon evenness	0.67	0.54	0.51	0.31	0.63	0.53±0.06
Whittaker beta diversity	1.82	4.96	3.22	2.36	2.38	2.94±0.55
Species turnover	1.86	6.48	3.27	2.22	2.65	3.29±0.82

Abbreviation as in Table 1; * only woody species data used for Yayu but for others all higher plants data were used.

Table 5. Abundance and frequency of wild coffee populations and some characteristics of the study quadrats in the studied Afromontane forests.

Characteristics	BO*	BK	HA	MA	YA
Abundance coffee per quadrat (range)	1–816	1–1007	1–1743	42–1123	117–2020
Median of coffee abundance	51	46	18	385	901
Percent frequency of coffee	93	91	71	100	100
Altitude (range) (m)	1772–2050	940–1780	1492–1830	1500–1620	1310–1550

Abbreviation for site code as in Table 1.

The basal area ranged from 46 to 54 m2 in the order of Berhane-Kontir > Maji > Harenna > Bonga > Yayu (Table 6). The highest and lowest densities of woody plants were recorded in Yayu (69,130 individuals/ha) and Harenna (9309 individuals/ha) forests, respectively (Table 6).

Ordination

The ordination of the study quadrats of the four forests resulted in five groups, mainly, based on the species composition (Fig. 3). The four groups reflected the four forest regions, namely Berhane-Kontir, Bonga, Harenna and Yayu, while the fifth group, *i.e.* "Coffee Forest," represents quadrats from the mid altitude (1,300–1,700 m) across all the four forests (Fig. 3). This is a forest belt in each forest where the floristic composition and/or coffee abundance are very similar. The high degree of dispersion of the quadrats inside the DCA diagram indicates the floristic heterogeneity of the forests.

The lengths of the maximum gradient axes for the different groups were greater than 4.5 standard deviation unit, indicating an almost total species change between the forests (McCune and Grace, 2002). The eigenvalue for the first axis (0.56) is much higher, indicating that this axis is strongly related to the most important environmental variables. Axis 1 of the ordination diagram reflects the gradient in altitude and axis 2 reflects the gradient of complex environmental factors. The distance between the forests indicates the relative degree of similarity or difference in terms of floristic composition or other environmental variables. The ordination also illustrated that there is some over-lapping between Yayyu and Berhane-Kontir forests (Fig. 3).

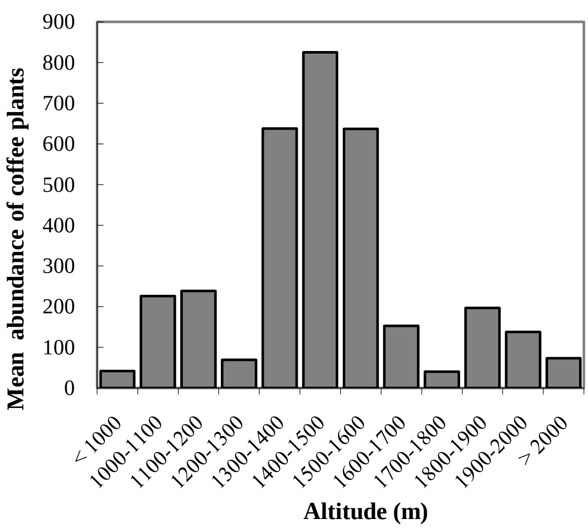

Figure 2. Mean abundance of wild coffee per quadrat along the altitudinal gradient in the studied Afromontane forests in Ethiopia.

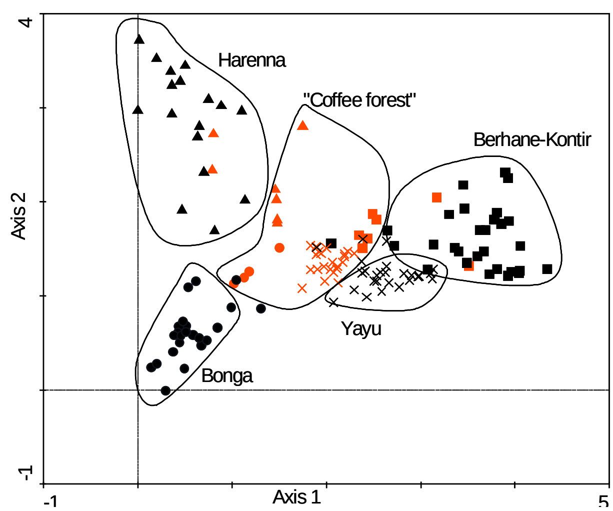

Figure 3. Ordination based on Detrended Correspondence Analysis (DCA) with abundance of woody species from four studied forests of Ethiopia (One symbol represents one site and the triangle represent the coffee populations).

Table 6. Relative density (%), density/ha and basal area of woody plants in the studied Afromontane forests.

DBH class	BO*	BK	MA	HA	YA
2–5 cm	69	64	61	45	46
5– 11 cm	22	17	20	31	32
11–23 cm	6	9	11	16	15
23–47 cm	2	6	5	5	5
> 47 cm	1	3	3	4	3
Density/ha	19,232	18,981	18,183	9,309	69,130
Basal area (m^2/ha)	47	54	53	49	46

*Abbreviations as in Table 1

DISCUSSION

Species richness

The species richness from the present study constitutes more than 10% of the higher plant species reported for the flora of Ethiopia (Tewolde-Berhan G/Egziabher, 1991). Many authors have noted the floristic impoverishment of Afromontane forest of Ethiopia as compared to other Africa rainforests due to the difference in the anthropogenic and environmental factors (White, 1978; Friis, 1992; Tamrat Bekele, 1994; Friis *et al*., 2001). However, most Afromontane forest species are rare and restricted in their range of distribution. Rare taxa are those having low abundance or small ranges (Gaston, 1994). Any combination of biological or physical factors or both could restrict the species in terms of either abundance or area coverage (Cowling, 1990; Goldblatt, 1997). More importantly, there are many economically useful plant species that are restricted to these forests. In particular, the last genetic base of the wild populations of *Coffea arabica*, for example, is housed in these forests. On the other hand, the disparity in the species composition observed among the studied forests might be due to the differences in the sampling size and intensity as well as historical and environmental factors.

The top 10 species-rich families in each forest were very similar even though their order changed in each forest. Some of these families (*e.g*., Euphorbiaceae, Rubiaceae, Moraceae, Asteraceae and Fabaceae) are always among the top 10 species-rich families in many neotropical forests and in Asia (Gentry, 1988). However, there are some families with restricted distribution range. Most of these families are found in the Berhane-Kontir forest. This forest belongs to the transition rainforest between the lowland forest and the moist evergreen Afromontane forest (Friis, 1992), and, hence, is composed of a very different suite of plant families than the other moist evergreen Afromontane forests (*e.g*., Nyctaginaceae and Violaceae).

On the other hand, the local endemic flora accounted for nearly 5% of the total species observed in the studied forests. Low endemicity is a common phenomenon in the Afromontane forest of SW Ethiopia (Friis *et al*., 2001) and Afromontane Region (White, 1978).

Floristic similarities

Despite the geographical distance, high floristic similarities were observed between the Bonga and Harenna forests. If the floristic similarity had been due to geographical distance, a high floristic similarity would have been observed between Bonga and Berhane-Kontir, which are located very close to each other (around 150 km), than the Harenna forest, that is, 10 times farther away. This could be explained by random variation, historical factors, and environmental determinism (Cowling, 1990; Lovett *et al*., 2000).

As a group, a comparison between the southeast (Harenna) and southwest (Bonga, Yayu, Maji and Berhane-Kontir) forests revealed 60% and 44% floristic similarity at family and species levels, respectively. The southwest moist evergreen Afromontane forest is species-rich compared with those in the southeast. The southwest Afromontane forest comprises relatively large tracks of forests, and has extensions to other forest vegetation resources in the area. More importantly, the southeast Afromontane forest is isolated from the rest of the moist evergreen Afromontane forests, and this may have limited the dispersal and migration of plant species. Furthermore, changes in the floristic composition of vegetation due to human impact have a long history in Ethiopia (Bonnefille and Hamilton, 1986; Darbyshire *et al*., 2003). Using pollen analysis, Bonnefille and Hamilton (1986) noted the destruction of montane forest in south-eastern Ethiopia as far back as *ca*. 2000 years. Although there are only few palynological analyses from Southwest Ethiopia, it can be assumed that these historical factors may have also led to the variation in floristic diversity between the two highlands.

Patterns of diversity

Effects of human activities on biodiversity can be measured and monitored based on indices of alpha, beta and gamma diversity (Perlman and Adelson, 1997; Halffter, 1998). The richness and evenness of the studied forests vary considerably. These differences are primarily a function of differences in site productivity, habitat heterogeneity and/or disturbance factors (Halffter, 1998; Petraitis *et al*., 1989; Maestre, 2004). For example, the low species richness and evenness in the Maji forest are due to anthropogenic disturbances such as burning, grazing, and wood collection, which have significantly reduced species richness (Personal observation). Lower evenness indicates the dominance of a few species. Several studies (*e.g*., Petraitis *et al*., 1989; Maestre, 2004) have highlighted the influence of human activities on species richness in different ecosystems. The low values of the Shannon diversity index of Maji forest also support the hypothesis of dominances of few early successional species and/or few species due to selective cutting of other species (Bone *et al*., 1997). Generally, the difference in the values of alpha diversity among the studied forests is an indicator of disturbance level difference.

Beta diversity is expected to be high in a fragmented tropical landscape because of the disparity of habitats (Shmida and Wilson, 1985; Moreno and Halffter, 2001). In the present study, a high level of species change was observed in the Berhane-Kontir forest reflecting the high degree of habitat heterogeneity due to topographic and moisture gradients. This forest has a high level of variability in environmental gradients, such as elevation, slope, aspect, soil types, and human forest uses as compared to other forest sites (Feyera Senbeta, 2006; Feyera Senbeta *et al*., 2007). The low value of beta diversity in the Bonga forest might be associated with high habitat homogeneity or to a large proportion of generalist species. This means that a careful analysis of beta diversity is vital for the selection of conservation areas (Bridgewater *et al*., 2004).

Measuring and monitoring species diversity at the regional/landscape level allows the assessment of the dynamic processes among the spatial components of biodiversity (Halffter, 1998).There were variations in the gamma diversity among the studied forest sites. High gamma diversity in the Berhane-Kontir forest is indicative of the existence of varied climatic and physical environmental conditions in the region, which also supported the fact that it is a transitional rainforest. A similar study from the neotropical montane forest showed that a transitional forest exhibited elevated species richness (Valencia, 1995; Ferraz *et al*., 2004). The Maji forest had the lowest gamma diversity compared with the other forests, which could be attributed to geographical isolation, human influence, effects of local climactic variation and size of the forest. According to local sources (personal communication with elders), human influence has been observed for many years, and most of the area occupied by forest today probably used to be farmland. In addition, geographical isolation might have also contributed to the low diversity in this forest, because it is surrounded by large tracts of dry and lowland vegetation.

Vegetation structure

In most studied forests, the overall patterns of population structure were inverted J-shaped types, which indicate normal population distributions with a high number of individuals in the lower size classes and only few individuals in the higher size classes. This pattern is an indicator of healthy regeneration of the forest and species, and shows a good reproduction and recruitment capacity (Tamrat Bekele, 1994).

Moist evergreen Afromontane forests have high densities of individuals, which, however, differ between sites. These differences may be explained by the complex interactions of the different historical factors. For example, the high plant densities in the Yayu forest might be attributed to the successional stage of the forest. Many natural disturbances, such as fire, may affect the succession processes of a forest. The Yayu forest may have been subjected to some disturbances in the past (Tadesse Woldemariam, 2003; Tadesse Woldemariam *et al*., 2008). During early successional development, many pioneer species may establish and grow together in high density until they reach the climax stage where many individuals are eliminated due to competition (Ewel, 1983). The low density in the Harenna forest is related to heavy human-related disturbances.

There was little difference among the studied Afromontane forests concerning the basal area per hectare. Site productivity, competition and/or density affect the basal area of the forests and stands. However, the present basal area values are slightly higher than those reported for tropical forests (Phillips *et al*., 1994). This might be due to a high density of individuals in the studied Afromontane forests. According to the reports of Gentry (1988), the densities of woody plants in the montane forests of Africa are relatively higher than other tropical montane forests. This may have contributed to the high basal area in the studied Afromontane forests.

Distribution of wild coffee populations

Species distribution patterns reflect the multitude responses that make up the capacity of a species to survive and reproduce under a particular set of conditions (MacArthur, 1972; Buckley and Kelly, 2003). In Ethiopia, populations of wild Arabica coffee occur over wide ranges of geographical regions, but they were patchily distributed in each studied forest. Although the absence of a species from a site or habitat may not indicate that the species cannot tolerate those conditions, the presence of a species signifies that it can. The locally patchy distribution of wild coffee plants in the forests might be due to habitat patchiness, substrate/geology, dispersal limitation, competition or degree of human influence (Vuilleumier and Simberloff, 1980). Therefore, the difference in the abundance and distribution of wild coffee plants among the studied sites and quadrats could also be related to these factors.

The highest mean abundance of coffee individuals per quadrat between 1,300 and 1,600 m suggests the optimum altitude of wild coffee. Mesfin Tadesse and Lisanework Nigatu (1996) reported similar results for the Harenna forest. Several other studies (*e.g.*, Hamilton, 1975; Friis, 1992; Wolf, 1994) have also shown the influence of altitudinal gradients on tree species distribution. Friis (1992) argued the existence of critical altitudes for groups of species in north-eastern tropical Africa with a separation between montane and lowland species at or below 1,500 m. This also holds true for wild populations of Arabica coffee, which exhibited preference to the altitudinal range of 1,300–1,600 m.

A high number of wild coffee plants were recorded in the quadrats where there was some sort of disturbance and/or on sites where there was little undergrowth, *e.g.,* at Maji or Yayu forests. In contrast, in the Harenna forest, where frequent livestock grazing is common, the abundance of coffee per quadrat was very low compared with those in the other forests. Heavy disturbance may lead to the establishment of few coffee plants only on suitable micro-sites where the disturbance is minimal. It can be concluded that severe disturbance may limit recruitment and establishment of coffee, while intermediate disturbances (*e.g.,* thinning of undergrowth) enhance the regeneration of coffee plants. Tadesse Woldemariam (2003) reported similar findings from the Yayu forest.

The negative relationship between the abundance of coffee plants and species richness indicates the inability of coffee to withstand competition. Coffee is highly sensitive to competition from shrubs and small trees (Demel Teketay, 1999). It is because of this sensitivity of coffee plants to competition that farmers usually remove or thin-out the competing trees and shrubs in order to improve the productivity of wild coffee plants whenever they manage coffee forests.

Vegetation distribution versus environmental factors

Plant community distribution in landscapes is the manifestation of physical gradients (*e.g.,* elevation gradient, soil heterogeneity and microclimate), biotic response to these gradients and historical disturbances (Urban *et al.*, 1987; Lima and Zollner, 1996; Urban *et al.*, 2000). Various ordination and clustering methods have been found to be robust and useful in ecological studies that consider patterns of vegetation composition and factors affecting species abundances (*e.g.*, McCune and Grace, 2002). In the present study, the multivariate analysis showed the patterns of floristic grouping within the studied Afromontane forests, suggesting a clear indication of floristic heterogeneity in the studied Afromontane forest fragments. The fact that Afromontane forests contain distinct floristic groups becomes relevant in terms of efforts to better understand and define the forest with respect to conservation. The floristic heterogeneity of the Afromontane forests is based on the difference in altitudes of the localities, local landscape, exposure, rainfall, type and depth of the soils, geological history, and anthropogenic factors (von Breitenbach, 1961; Hedberg, 1964; Friis, 1992; Tadesse Woldemariam, 2003).

Several authors (*e.g.*, Hedberg, 1964; Lisanework Nigatu and Mesfin Tadesse, 1989) have noted the presence of an altitudinal zonation in the forest vegetation of Ethiopia. Altitudinal gradients are complex gradient and involve many different interacting factors such as topography, soil, moisture and climate (Hedberg, 1964; Austin *et al*., 1996), which in turn influence the growth and development of plants, and the patterns of vegetation distribution. Of these complex variables, which are difficult to separate, temperature and other climatic variables seem to be most important for describing species richness or community via the altitudinal gradient (Körner, 2000). The position of each Afromontane forest area with respect to altitudinal gradient was difficult to separate since most of the forests had overlapping ranges of altitude, especially between 1,400 and 1,800 m. However, there is vegetation variation (for example in species composition, diversity and structure) along the altitudinal gradient in each forest. A good example is the Harenna forest, where a clear vegetation zonation is observed. The lowest most portion of the forest, between 1,400 and 1,500 m, is relatively dry and dominated by *Podocarpus falcatus-Strychnos mitis* plant community. Between 1,600 and 1,800 m, there is a zone of high humidity with the *Podocarpus falcatus-Syzygium guineense* plant community. In each of these zones, many different trees and shrub species are associated.

The amount and patterns of rainfall distribution also differ in the different studied forests. There is a general pattern of maximum rainfall in the southwest, particularly around the Berhane-Kontir forest (total annual rainfall > 2000 mm), while rainfall decreases (800–1000 mm) toward the southeast where Harenna forest is located. This is probably the reason for the different plant communities found in each forest region. The difference in the composition of species, at least in the dominant canopy species, between the southwest and southeast moist Afromontane forests is evident. In the Harenna forest, *Podocarpus falcatus*, mainly, dominate the tree canopies, whereas in the southwest forests (*e.g.*, Berhane-Kontir) a mixture of broadleaved species dominates the canopies, *e.g.*, *Pouteria* spp., *Olea welwitschii, Manilkara butugi* and *Ficus* spp.

The ordination results of five groups of communities in the present study suggest the existence of differences in several environmental factors among the study forests. The major separating feature of the identified groups is the difference in dominant plant species or indicator species in each locality. Indicator species have been commonly used in reserve selection and for making decisions about the reserve design (Sarakinos *et al*., 2001). It appears that species frequently show marked preferences for specific environmental conditions. Except for the coffee community, which is the amalgamation of quadrats from all forest sites, all other plant communities identified in the present analysis follow regional differences. Generally, geographical isolation is the main source of variation, which contributes to the variation in physical and climatic factors between the communities or forests. In each region, a number of biotic and abiotic factors may further influence the plant community.

Some tree species associated with the Yayu and Berhane-Kontir forests are linked to Guineo-Congolian floral elements. The Berhane-Kontir and Yayu forests can be therefore categorized as "transitional rainforest". This is in accordance with the findings of Friis (1992). On the other hand, Harenna and Bonga, although differing in plant community, are both related to montane forests. All studied forests shared the *Coffea arabica* populations as species linking geographically separated moist Afromontane forests although they varies in some aspects.

CONCLUSION

The studied Afromontane rainforests support high plant species diversity and are a refuge for wild Arabica coffee populations. These give them an exceptional key function for the conservation of the genetic resources of Arabica coffee in the world. Furthermore, they shelter a great number of other economically useful plant species on which the local communities depend for their livelihoods, *e.g., Aframomum corrorima, Dioscorea* spp., *Piper capense;* and others. Despite their ecological and economic importance, however, the Afromontane forests of Ethiopia are being affected by habitat modification, over-harvesting, commercial plantations and agricultural expansion. The long-term survival of the Afromontane forests will therefore depend on large-scale conservation efforts. Conservation of forest genetic resources, including wild coffee populations, will only be possible if the use of the Afromontane forests is sustainable. As the studied Afromontane forests are ecological diverse, it is recommended that conservation strategies should focus on multiple-sites conservation networking in order to encompass a range of forests in the conservation system.

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Appendix 1. List of vascular plant species recorded from studied Afromontane forests of Ethiopia (Growth form: TT- Tall tree greater than 30 m in height at maturity; MT-Medium tree, with height of 15-30 m at maturity; St- Small tree, less than 15 m tall; RT- rosette tree; S- shrub; C-climbers; H- Herb; E-Epiphytes; G- Grasses and Sedges). Prsence of species in each study site is indicated by tallying study forest (s) as [BK-Berhane-Kontir; BO-Bonga; HA-Harenna; MA-Maji; YA-Yayu; ALL-presence in all sites].

A. **PTERIDOPHYTA**

ADIANTACEAE (C. Presl) Ching
Adiantum philippense L., **H, [BK, BO, YA]**
Cheilanthes farinosa (Forssk.) Kaulf. , **H,[BO, HA]**
Coniogramme africana Hieron. **E, [BK, BO]**
Doryopteris concolor (Langsd. & Fisch.) Kuhn , **E, [BK}**
Pellaea doniana Hooker, **E**, [**BK**]
P. viridis (Forssk.) Prantl, **E, [BK]**

ASPIDIACEAE S.F. Gray
Ctenitis cirrhosa (K. Schum.) Ching, **H, [BK, BO]**
Didymochlaena truncatula (Swartz) J. Sm., **H, [BK]**
Dryopteris inaequalis (Schlech.) Kuntze, **H,[BO, MA]**
Polystichum fuscopaleacum Aliston , **E, [HA]**
Polystichum transvaalense N.C. Anthony, **E, [BO]**
Tectaria gemmifera (Fee) Alston, **E,[BK,BO,HA,MA)**

ASPLENIACEAE L.
Asplenium aethiopicum (Burm. F.) Becherer, **E, [BK, BO, MA)**
A. anisophyllum Kze.,**E,[BK, BO, MA)**
A. buettneri Hieron,**E,[BO, MA, YA)**
A. bugoiense Hieron,**E,[BK, BO, MA, YA)**
A. ceii Pichi-Serm. **E,[BO]**
A. elliotti C.H.Wright,,**E, [BO, HA]**
A. erectum Willd., **E, [BK, BO, MA]**
A. friesiorum C.Chr.,**E,[BK]**
A. hypomelas Kuhn.,**E,[YA, MA]**
A. inaequilateriale Willd,**E, [BO, YA]**
A. linkii Webb,**E, [BO, MA]**
A. mannii Hook.,**E, [BK, MA]**
A. nidus, E, [BK]
A. sandersonii Hook,**E, [BK, BO, HA, MA, YA]**
A. stenopterum Peter,**E, [BK, MA]**
A. theciferum (Kunth.) Mett.,**E, [BO, MA, YA]**

ATHYRIACEAE Alston
Athyrium schimperi Fee [1a],**E, [BO, HA]**

CYATHEACEAE Kaulf.
Cyathea manniana Hook. , **RT, [BK, BO, HA, YA]**

DENNSTAEDTIACEAE Pichi-Serm.
Blotiella glabra (Bory) Tryon, **H, [BK,BO]**
Microlepia speluncae (L.) S. Moore, **H, [BK, BO]**
Pteridium aquilinum (L.) Kuhn, **H, [BK]**

LOMARIOPSIDACEAE Alston
Elaphglossum deckenii (Kuhn) C. Chr., **E, [BK, BO, YA]**

LOXOGRAMMACEAE Ching
Loxogramme lanceolata (Sw.) Presl., **E, [BK, BO, YA]**

LYCOPODIACEAE Mirbel
Lycopodium clavatum L., **E, [BK, BO, HA]**
Lycopodium dacrydioides Baker, E, [BO]

MARATTIACEAE Bercht. & J. Presl
Marattia fraxinea Gmel, **E, [BO]**

OLEANDRACEAE Pichi-Serm.
Arthropteris monocarpa (Cord.) C. Chr., **E, [BK, BO, MA,YA]**
Oleandra distenta Kunze,.**E, [BO, HA]**

POLYPODIACEAE Bercht. & J. Presl
Drynaria volkensii J. Sm, **E, [BK, BO, HA, YA]**
Microsorium punctatum (L.) Copel., **E, [BO, MA]**
M. scolopendrium (Burm. f.) Copel., **E, [BK]**
Phymatosorus scolopendria (Burm. F.) Ching,,**E, [BK]**
Platycerium elephantotis Schweinf.., **E, [BK]**
Pleopeltis excavata (Willd.) Sledge, **E, [BK, BO]**
P. macrocarpa (Willd.)Kaulf., **E, [BO, MA]**

PTERIDACEAE (Gray) Gaudich
Pteris catoptera Kunze, **E, [BK, BO, MA]**
P. cretica L., **E, [BK, BO, MA]**

P. dentata Forssk., **E, [BK, BO, MA]**

SELAGINELLACEAE Milde
Selaginella kraussiana (Kze.) A. Br., **E, [HA, MA}**

THELYPTERIDACEAE Pichi-Serm.
Cyclosorus dentatus (Forssk.) Ching, **H, [BK]**

VITTARIACEAE C. Presl
Vittaria guineensis Desv., **E, [BO]**

B. **GYMNOSPERMAE**
CUPRESSACEAE Bartling
Juniperus excelsa Bieb.1b, 3, 4b], **TT, [HA]**

PODOCARPACEAE Endl.
Podocarpus falcatus (Thunb) C.N., **TT, [BO, HA, YA]**

C.ANGIOSPERMAE-DICOTYLEDONAE
ACANTHACEAE Juss.
Acanthus eminens C.B.Cl., **S, [BK, BO, HA, MA, YA]**
Asystasia schimperi T. Anders, **H, [HA]**
Brillantaisia grotanellii Pichi-Sermoli,**S, [BK, YA]**
Crossandra massaica Oliv,**H, [BK, YA]**
Dicliptera laxata C.B.Cl., **H**, [BO]
Hypoestes aristata (Vahl) Röm. & Schultes,**H, [BO, HA]**
H. forskaoli (Vahl) Röm. & Schultes, **H, [BK, BO, HA, MA, YA]**
H. triflora (Forssk.) Roem & Schult, **H, [HA, MA]**
H. verticillaris (L. f.) Röm & Schult, **H, [HA]**
Isoglossa somalensis Lindau, **C, [BO]**
I. punctata (Vahl) Brummit & J.R.I.Wood, **C, [BO, HA]**
Justicia betonica L. **H, [BK, YA]**
J. diclipteroides Lindau, **H, [BK, BO]**
J. flava (Forssk.) Vahl ,**H, [BK]**
J. glabra Roxb., **H, [BO, MA, YA]**
J. heterrocarpa T. Anderson, **H, [YA]**
J. schimperiana (Hochst.ex A.Rich.) T.Anders,**S, [ALL]**
Mellera lobulata S. Moore, **H, [BK]**
Metarungia pubinervia (T. Anders) Baden, **S, [BK]**
Monothecium glandulosum Hochst, **H, [BK]**
Phaylopsis longifolia Sims, H, [HA]
Rungia grandis T. Anders, **S, [BK]**
Ruspolia seticalyx Lindau, **H, [BK]**
Thunbergia fasciculata Lindau, **C, [BK]**
Whitfieldia elongata (Beauv.)Wild. &T.Dur , **S, [BK]**

ALANGIACEAE DC.
Alangium chinense (Lour.) Harms, **ST, [BO, HA]**

AMARANTHACEAE Juss.
Achyranthes aspera L., **H, [BK, BO, HA, MA, YA]**
Amaranthus hybridus L., **H, [BK, YA]**
Celosia argentea Schinz, **H, [BK, MA]**
C. schweinfurthiana Schinz, **H,[BK, HA]**
C. trigyna L., **H, [BK, YA]**
Cyathula cylinderica Moq., **H, [BO, HA]**
C. uncinulata (Schrad.) Schinz , **H, [BK, BO, MA]**
Gompherena celosioides Mart. ,**H ,[YA]**
Pupalia lappacea (L.) A. Juss , **C, [HA, MA]**
Sericostachys scandens Gilg & Lopr., **C, [BK, BO]**

ANACARDIACEAE Lindl.
Lannea welwitschii (Hiern) Engl., **MT, [BK]**
Ozoroa insignis Del.,T, **[HA]**
Rhus natalensis Krauss , **S, [HA]**
R. ruspolii Engl, **S, [YA]**
R. quartiniana A. Rich., **S, [YA]**

ANNONACEAE Juss.
Annona senegalensis Pers., **C, [BK]**
Artabotrys monteiroae Oliv. , **C, [BK]**
Asteranthe asterias (S.Moore) Engl. & Diels, **C, [MA]**
Monanthotaxis parvifolia (Oliv.)Verdc, **C, [BK, MA]**
M. ferruginea (Oliv.) Verdc., **C, [BK]**
Uvaria angolensis Oliv. , **C, [BK, MA]**
U. leptocladon Oliv. , **C, [BK]**
U. schweinfurthii Engl. & Dieles, **C, [BK]**
Xylopia parviflora (A. Rich.) Benth1, **MT, [BK]**

APIACEAE (UMBELLIFERAE Juss.)
Agrocharis incognita (Norman) Heyw.&Jury, **H, [BO]**
Cryptotaenia africana (Hook.f.) Drude, **H, [BO]**
Pimpinella heywoodii Abebe, **H, [BO, HA]**
Sanicula elata Buch.-Ham. ex D. Don, **H, [BK, BO, HA]**
Steganotaenia araliacea Hochst ex.A. Rich., **H, [HA]**

APOCYNACEAE Juss.
Alstonia boonei De Wild., **TT, [BK, MA]**
Carissa spinarum L. , **C, [ALL]**
Landolphia buchananii (Hall.f.) Stapf, **C, [ALL]**
Oncinotis tenuiloba Stapf , **C,[ALL]**
Saba comorensis (Boj.) Pichon , **C, [BK]**

AQUIFOLIACEAE Bartl.
Ilex mitis (L.) Radlk., **MT, [BO]**

ARALIACEAE Juss.
Polyscias fulva (Hiern) Harms, **MT, [ALL]**
Schefflera abyssinica Forst. & Forst. f., **MT, [BO, HA, YA]**
S. myriantha (Bak.) Drake, **C, [BO, HA]**

ASCLEPIDACEAE R. Br.
Ceropegia nilotica Kotschy , **C, [BK, BO]**
C. sankurensis Schltr., **C, [BO]**
C. sobolifera N.E.Br., **C, [BK, HA]**
Dregea schimperi (Decne.) Bullock, **C, [HA]**
Gomphocarpus semilunatus A. Rich., **H, [YA]**
G. fruticosus (L.) Ait.f., **H, [YA]**
Leptadenia hastata (Pers.) Decne., **C, [BK]**
Pentatropis nivalis D.V.Field & J.R.I.Wood, **C, [BK]**
Pentarrhinum insipidum E. Mey., **C, [BO]**
Periploca linearifolia Quart-Dill. & A. Rich., **C, [BO,YA]**
Secamone parvifolia (Oliv.) Bullock, **C, [HA]**
S. punctulata Decne, **C, [BK, MA]**
Tacazzea apiculata Oliv., **C, [BO, HA, MA]**
T. conferta N.E.Br., **C, [BO]**
Tylophora sylvatica Decne., **C, [BK]**

ASTERACEAE L.
Adenostemma mauritianum DC, **H, [BK, BO]**
Ageratum conyzoides L., **H, [BK, BO, HA, YA]**
Aspilia mossambicensis (Oliv.) Wild., **S, [BO, HA]**
A. africana (Pers.) Adams, **S, [[BO, HA]**
Bidens pachyloma (Oliv. & Hiern)Cufod., **H, [BK, HA]**
B. prestinaria (Sch.Bip.)Fiori., **H, [HA}**
Botheriocline fusca Oliv. & Hiern, **S, [BO, HA]**
B. schimperi Oliv. & Hiern ex Benth, **S, [HA]**
Carduus nyassanus (S. Moore) R.E.Fries, **H, [HA]**
Conyza variegata Sch.Bip. ex A. Rich., **H, [HA]**
C. abyssinica Willd. , **H, [HA]**
Crassocephalum montuosum (S. Moore)Milne-Redh., **H, [BO, YA]**
Dicrocephala integrifolia (L.f.) Kuntze, **H, [HA]**
Galinsoga parviflora Cav. , **H, [BK, BO, MA, YA]**
Laggera crispata (D. Don) Oliv , **H, [BO]**
L. pterodonta (DC.) Sch. Bip. ex Oli, **H, [BO, YA]**
L. tomentosa (Sch.Bip. ex A.Rich.)Oliv. & Hiern, **H, [BK]**
Microglossa pyrifolia (Lam.) Kuntze, **C, [BO]**
Solanecio gigas (Vatke) C.Jeffrey, **S, [BK, HA, YA]**
Sphaeranthus bullatus Mattf , **H, [HA]**
Spilanthes costata Benth. , **H, [BK]**
S. mauritiana Benth., **H, [BO]**
Tagetes minuta L., **H, [HA]**
Vernonia adoensis Sch. Bip. ex walp, **S, [HA]**
V. amygdalina Del., **S, [BK, BO, HA, YA]**
V. auriculifera Hiern., **S, [BK, BO, HA, YA]**
V. biafrae Oliv. & Hiern, **C, [BO, MA]**
V. hochstetter Sch. Bip. ex walp, **S, [HA, YA]**
V. leopoldi (Sch. Bip. ex walp) Vatke, **S, [MA]**
V. wollastonii S. Moore, **C, [BO]**

BALANOPHORACEAE
Thonningia sanguinea Vahl, **H, [BK]**

BALSAMINACEAE A. Rich.
Impatiens ethiopica Grey-Wilson, **H, [BK, BO, YA]**
I. hochstetteri Warb., **H, [BO, YA]**
I. rothii Hook.f., **H, [BO, HA]**

BASELLACEAE Moq.
Basella alba L., **C, [HA]**
BIGNONIACEAE Juss.
Stereospermum kanthianum Cham., **ST, [HA, BK]**

BORAGINACEAE Juss.

Cordia africana Lam., **MT, [ALL]**
Cynoglossum coeruleum A.DC, **H, [BO, MA, YA]**
Ehretia cymosa Thonn. , **MT, [ALL]**

BRASSICACEAE Burnett
Cardamine africana L., **H, [BO, YA]**
C. trichocarpa A. Rich., **H, [BK, BO, YA]**

CACTACEAE Juss.
Rhipsalis baccifera (J. Miller) W.T. Stearn, **E [BK, BO, MA, YA]**

CAMPANULACEAE Juss.
Canarina abyssinica Engl., **E, [BO, HA]**
C. eminii Schweinf, **E, [HA]**

CANELLACEAE Mart.
Warburgia ugandensis Sprague, **MT, [HA]**

CANNACEAE Juss.
Canna indica L. , **H [YA]**

CAPPARIDACEAE Juss.
Capparis erythrocarpos Isert, **C, [BK, MA, YA]**
C. micrantha A. Rich, [HA, **YA]**
C. tomentosa Lam., **C, [BK]**
Ritchiea albersii Gilg, ST, **[BK, MA, YA]**

CARYOPHYLLACEAE Juss.
Drymaria cordata (L.) Schultes, **C, [BK, BO, HA]**
Stellaria mannii Hook.f., **C, [BO, HA]**
S. media (L.) Vill., **C, [HA}**

CELASTRACEAE R. Br.
Catha edulis (Vahl) Forssk. ex Endl , **S, [BO]**
Elaeodendron buchananii (Loes) Loes., **MT, [ALL]**
Hippocratea africana (Willd.) Loes., **C, [ALL]**
H. goetzei Loes, **C, [BK, BO, HA]**
H. pallens Planchon. ex Oliver , **C, [BK, MA]**
H. parvifolia Oliver , **C, [BK, MA]**
Maytenus arbutifolia (A. Rich.) Wilczek, **S, [BO, HA, MA, YA]**
M. gracilipes (Welw. ex Oliv.) Exell, **S, [ALL]**
M. senegalensis (Lam.) Exell, **S, [HA, MA]**
M. undata (Thunb.) Blakelock, **S, [HA]**
Salacia congolensis De Wild & Th. Dur., **C, [BK, MA]**

CHENOPODIACEAE Vent.
Chenopodium procerum Moq., **H, [BO]**

COMBRETACEAE R. Br.
Combretum aculeatum Vent., **S, [BK]**
C. capituliflorum Steud. ex A. Rich., **S, [BK]**
C. molle R.Br. ex G.Don, T, [HA]
C. paniculatum Vent., **C, [BK, BO, MA, YA]**
Terminalia brownii Fresen., **ST, [MA]**

CONVOLVULACEAE Juss.
Ipomoea carica (L.) Sweet, **C, [BK, HA, YA]**
I. hochstetteri House, **C, [YA]**
I. tenuirostris Steud. ex Choisy, **C, [BO, YA]**
Stiotocardia beraviensis (Vatke) Hall.**H, [BK]**

CRASSULACEAE DC.
Crassula alsinoides (Hook.f.) Engl., **H, [HA]**
C. schimperi Fisch. & Mey, **H, [HA]**
Kalanchoe densiflora Rolfe, **H, [BK, YA]**
K. lanceolata (Forssk.)Pers, **H, [HA]**
K. petitiana A. Rich., **H, [BO]**

CUCURBITACEAE Juss.
Coccinia schliebenii Harms., **C, [BK]**
Cucumis ficifolius A. Rich., **C, [HA]**
Lagenaria abyssinica (Hook. f.) Jeffrey,**C, [YA}**
Momordica foetida Schumach, **C, [HA]**
Peponium vogelii (Hook.f.)Engl., **C, [BO, HA]**
Sicyos polycanthus Cogn, **C, [BK, YA]**
Zehneria minutiflora (Cogn.) C. Jeffrey,**C, [BK]**
Z. abyssinica (Hook.f.) Jeffery,**C, [BK]**
Z. scabra (L.f.) Sond., **C, [YA]**

DILLENIACEAE Salisb.
Tetracera stulmanniana Gilg., **C, [BK]**
EBENACEAE Gürke
Diospyros abyssinica (Hiern) F. White, **MT, [BK, BO, HA, MA, YA]**
D. mespiliformis Hochst. ex A.DC, **MT, [BK, HA, MA, YA]**
Euclea racemosa Murr., **S, [MA]**

ERYTHROXYLACEAE Kunth
Erythroxylum fischeri Engl., **ST, [HA]**

EUPHORBIACEAE Juss.
Acalypha acrogyna Pax, **S, [YA]**
A. frutocosa Forssk., **S, [BK]**
A. ornata A. Rich., **S, [BK, BO, MA, YA]**
A. psilostachya Hochst. , **H, [BO, YA]**
A. racemosa Baill. , **S, [YA]**
Alchornea laxiflora (Benth.) Pax & Hoffm, **S, [BK]**
Argomuellera macrophylla Pax, **S, [BK, MA, YA]**
Bridelia atroviridis Mull. Arg., **ST [BK]**
B. cathartica Bertol. f. , **ST, [BK]**
B. micrantha (Hochst.)Baill. , **ST, [BK, YA]**
B. scleroneura Mull. Arg., **ST, [BK]**
Croton macrostachyus Del. , **MT, [ALL]**
Erythrococca abyssinica Pax , **S, [BK]**
E. trichogyne (Muell. Arg.) Prain., **S, [BK, BO, HA, YA]**
Euphorbia ampliphylla Pax, **ST, [BO]**
E. omariana M. Gilbert, **H, [BO, HA]**
E. schimperiana Sheele, **H, [YA]**
Macaranga capensis (Baill.) Sim, **MT, [ALL]**
Margaritaria discoidea (Baill.) Webster, **ST, [BK, HA]**
Phyllanthus fischeri Pax, **H, [BK]**
P. limmunis Cuf., **S, [YA]**
P. mooneyi M. Gilbert, **H, [BO, MA]**
P. ovalifolius Forssk., **S, [BO, HA, MA, YA]**
P. sepialis Muell. Arg., **S, [HA]**
Ricinus communis L., **H, [BK, YA]**
Sapium ellipticum (Krauss) Pax, **MT, [BK, BO, MA, HA]**
Suregada procera (Prain) Croizat, **S, [HA]**
Tragia brevipes Pax, **C, [BK, BO, HA, MA)**
T. crenata M. Gilbert, **S, [BK]**

FABACEAE Juss.
Acacia abyssinica Hochst. ex Benth, **MT, [BK]**
A. brevispica Harms., **C, [BK, BO, HA]**
A. montigena Brenan & Exell., **C, [BK, HA]**
Aeschynomene elaphroxylon (Guill & Perr) Taub, **S, [BO]**
Albizia grandibracteata Taub., **MT, [BK,YA]**
A. gummifera (J. F. Gmel.) C.A.Sm., **MT, [BO, HA, YA]**
A. schimperiana Oliv. , **MT, [BO, MA, YA]**
Baphia abyssinica Brummitt, **MT, [BK]**
Caesalpinia decapetala (Roth) Alston, **C, [HA]**
C. volkensii Harms, **C, [HA]**
Calpurna aurea (Ait.) Benth, **ST, [ALL]**
Cassia arereh Del., **S, [HA]**
Crotalaria axillaris Ait., **S, [HA]**
C. karagwensis Taub, **S, [HA]**
C. keniensis Bak.f., **S, [HA]**
Dalbergia lactea Vatke, **C, [ALL]**
Desmodium hirtum Guill. & Perr, **H, [BK, BO, YA]**
D. repandum (Vahl) DC, **H, [BO, HA, MA, YA]**
Dolichos sericeus E. Mey., **C, [HA]**
Entada abyssinica Steud. ex A.Rich., **ST, [YA]**
Erythrina abyssinica Lam. ex DC, **ST, [HA]**
E. brucei Schweinf. , **ST, [HA}**
Lablab purpureus (L.)Sweet, **C, [HA, YA]**
Lotus discolor E. Mey, **H, [HA]**
*Millettia ferru*ginea (Hochst.) Bak., **ST, [ALL]**
Mimosa pigra L., **H, [BK, BO, YA]**
Pterolobium stellatum (Forssk.) Brenan, **C, [BK, HA, YA]**
Senna occidentalis (L.) Link, **S, [HA]**
S. petersiana (Bolle) Lock, **S, [BK, HA, YA]**
Sesbania dummeri Phil. & Hutch., **S, [HA]**
Trifolium rueppellianum Fres, **H, [HA]**

FLACOURTIACEAE DC.
Flacourtia indica (Burm.f.) Merr., **ST, [ALL]**
Oncoba routledgei Sprague, **ST, [HA]**

GERANIACEAE Juss.
Geranium aculeolatum Oliv., **H, [BO]**
G. arabicum Forssk., **H, [BO, HA]**

GUTTIFERAE Juss.
Garcinia buchananii Baker, **ST, [BK]**
G. livingstonei T. Anders., **ST, [BK]**

G. ovalifolia Oliver, **ST, [BK, HA, MA]**
Hypericum peplidifolium A. Rich., **H, [BO, HA]**
H. revolutum Vahl, **ST, [BO, HA]**

HAMAMELIDACEAE R. Br.
Trichocladus ellipticus Eckl. & Zeyh. , **S, [BK, HA, MA]**

ICACINACEAE Miers
Apodytes dimidiata E. Mey. ex Arn., **MT, [BK, BO, HA, YA]**
Raphiostylis beninensis (Planch.) Benth, **C, [BK]**
Pyrenacantha sylvestris S. Moore, **C, [BK]**

LABIATAE Juss.
Ajuga bracteosa Wall. ex Benth. , **H, [BO]**
A. alba (Gurke) Robyns, **H, [BO]**
Achyrospermum schimperi (Hochst.exBriq)Perkins, **H, [BK, BO, YA]**
A. parviflorum S. Moore, **H, [HA]**
Leucas urticifolia (Vahl)Sm., **H, [BO]**
Nepeta azurea R. Br. ex Benth, **H, [HA]**
Ocimum urticifolium Roth, **S, [HA]**
O. lamiifolium Hochst. ex Benth., **S, [BO, HA, MA, YA]**
Plectranthus punctatus (L.F.) L´H´er, **H, [BO]**
P. sylvestris Gurke, **H, [BK]**
P. laxiflorus Benth. , **H, [BK]**
Satureja simensis (Benth.) Briq, **H, [HA]**
S. paradoxa (Vatke) Engl. ex Seybold, **H, [HA]**
Salvia nilotica Jacq., **H, [HA]**
Stachys aculeolata Hook.f. , **C, [HA]**

LAURACEAE Juss.
Ocotea kenyensis (Chiov.) Robyns & Wilczek , **MT, [BO, HA, YA]**
Cassytha filiformis L., **H**, [YA]

LOBELIACEAE R. Br.
Lobelia giberroa Hemsl. , **S, [BK, HA]**
Monopsis stellorioides (Presl) Urban, **H, [BO]**

LOGANIACEAE Mart.
Anthocleista schweinfurthii Gilg , **MT, [BK]**
Buddleja polystachya Fresen, **S, [HA]**
Nuxia congesta R. Br. ex Fresen , **ST, [HA]**
Strychnos henningsii Gilg , **ST, [BK, HA]**
S. innocua Del., **ST, [BK]**
S. mitis S. Moore, **MT, [BK, HA, MA]**

MALVACEAE Juss.
Abutilon cecilii N.E.Br., **H, [YA]**
A. longicuspe Hochst. ex Garcke, **S, [HA, MA]**
Hibiscus calyphyllus Cavan., **H, [BK, HA, MA]**
H. diversifolius A. Rich., **S, [BO]**
H. ludwigii Eckl. & Zeyh, **S, [HA]**
Pavonia urens Cav., **H, [BO, YA]**
Sida acuta Burm.f. , **H, [HA]**
S. collina Schlechtend.**, S, [YA]**
S. ovata Forssk.**, S, [HA}**
S. rhombifolia L., **S, [BK, BO]**
S. ternata L., **S, [BK, HA, YA]**
Wissadula rostrata (Schumach & Thonn.) Ho.f., **H, [YA]**

MELASTOMATACEAE Juss.
Dissotis decumbens (P. Beauv.) Triana, **H, [BO]**
Tristemma mauritianum J.F.Gmel., **H, [BO]**

MELIACEAE Juss.
Ekebergia capensis Sparrm.**, MT, [BK, BO, HA, YA]**
Lepidotrichilia volkensii (Gurke) Leroy **,ST, [ALL]**
Pseudocedrela kotschyi (Schweinf.) Harms, **ST, [BK]**
Trichilia dregeana Sond., **MT, [BK, MA, YA]**
T. emetica Vahl. , **MT, [BK]**
T. prieuriana A. Juss., **MT, [BK, MA]**
Turraea holstii Gurke, **ST, [HA]**

MELIANTHACEAE Link
Bersama abyssinica Fresen, **ST, [ALL}**
MENISPERMACEAE Juss.
Cissampelos pareira L., **C, [BO]**
C.owariensis Beauv. Ex DC. , **C, [HA]**
Tiliacora funifera Oliv., **C, [BK]**
T. troupinii Cufod. , **C, [BK, BO, MA, YA]**
Tinospora caffra (Miers) Troupin, **C, [BO]**
Stephania abyssinica (Dillon & A. Rich.)Walp., **C, [HA]**
S. cyanantha Welw. ex Hiern, **C, [HA]**

MORACEAE Link
Antiaris toxicaria Lesch, **TT, [BK, YA]**
Dorstenia soerensenii Friis , **H, [BK, BO]**
D. barnimiana Schweinf., **H, [BK, BO]**
Ficus asperifolia Miq. , **ST, [BK]**
F.capreaefolia Del , **ST, [YA]**
F. exasperata Vahl. **, ST, [BK, HA, YA]**
F. lutea Vahl **, ST, [BK, MA, YA]**
F. mucuso Ficalho , **MT, [BK, YA]**
F. ovata Vahl , **ST, [BK]**
F. palmata Forssk. , **ST, [BK]**
F. sur Forssk., **MT, [BK, BO, HA, YA]**
F. sycomorus L., **MT, [BK, HA]**
F. thonningii Blume, **ST, [ALL}**
F. umbellata Vahl , **ST, [BK]**
F. vallis-choudae Del. , **ST, [BK, YA]**
F. vasta Forssk. , **MT, [BK, HA, MA]**
Milicia excelsa (Welw.) C. C. Berg , **TT, [BK]**
Morus mesozygia Stapf , **MT, [BK, YA]**
Trilepisium madagascariense DC., **MT, [BK, MA]**

MYRSINACEAE R. Br.
Embelia schimperi Vatke, **C, [BK, BO, HA, MA]**
Maesa lanceolata Forssk., **ST, [BK, BO, HA, YA]**
Myrsine africana L., **S, [H], [HA]**

MYRTACEAE Juss.
Eugenia bukobensis Engl., **ST, [BK, YA]**
Syzygium guineense ssp. afromontanum F.White, **MT, [BO]**
S. guineense ssp. guineense (Willd.)DC , **MT, [BO, HA]**
S. guineense ssp. macrocarpum F. White , **ST, [HA, MA]**

NYCTAGINACEAE Juss.
Pisonia aculeata L., **C, [BK]**

OLEACEAE Hoffsgg. & Link
Jasminum dichotomum Vahl, **C, [MA]**
J. abyssinicum Hochst. ex Dc, **C, [BK, BO, HA]**
Olea europaea L. ssp. cuspidata (Wall. ex G. Don) Cif. L'Olivicoltore, **ST, [BO, HA]**
O. capensis L.ssp. macrocarpa (C.H.Wright)Verdc., **MT, [BO, HA, YA]**
O. welwitschii (Knobl.) Gilg & Schellenb., **TT, [ALL]**
Chionanthus mildbraedii (Gilg&Schellenb.) Stearn, **S, [ALL]**
Schrebera alata (Hochst.) Welw., **ST, [ALL]**

OLINIACEAE Sond.
Olinia rochetiana A. Juss. , **ST, [BO, HA]**

OPILIACEAE Valeton
Opilia amentacea Roxb. , **C, [BK, MA]**

OXALIDACEAE R. Br.
Oxalis corniculata L., **H, [BO]**
O. radicosa A. Rich. , **H, [BK, HA, YA]**
O. procumbens Steud. ex A. Rich, **H, [BK, BO, HA]**

PASSIFLORACEAE Kunth
Adenia rumicifolia Engl., **C, [HA]**
Passiflora edulis Sims, **C, [BO]**

PHYTOLACCACEAE R. Br.
Hilleria latifolia (Lam.) H. Walter, **H, [BK, HA, MA, YA]**
Phytolacca dodecandra L´Herit. , **C, [BK, BO, HA]**

PIPERACEAE J. Agardh
Piper capense L.f., **H, [BK, BO, MA]**
P. guineense Schum. & Thonn., **C, [BK]**
P. umbellatum L. , **H, [BO]**
Peperomia abyssinica Miq., **H, [BK, BO, HA]**
P. fernandopoiana C. DC. , **H, [BK, BO]**
P. molleri C. DC.**, H, [BK, BO, MA]**
P. retusa (L.f.) A.Dietr., **H, [BO]**
P. rotundifolia (L.) Kunth, **H, [BO]**
P. tetraphylla (Forster) Hook & Arn., **H, [BK, BO, HA, MA]**

PITTOSPORACEAE R. Br.
Pittosporum viridiflorum Sims**, ST, [ALL]**

PLUMBAGINACEAE Juss.
Plumbago zeylanica L., **C, [BK, HA]**

POLYGONACEAE Juss.
Rumex abyssinicus Jacq., **S, [BO]**
Persicaria decipiens (R. Br.) K.L. Wilson , **H, [BO]**
P. nepalensis (Meisn.)Miyabe , **H, [BO]**
P. senegalensis (Meisn.) Sojak, **H, [BO]**

PRIMULACEAE Vent.
Ardisiandra sibthorpioides Hook. F., **H, [BO]**

RANUNCULACEAE Juss.
Clematis longicauda Steud. ex A. Rich., **C, [BK, BO, YA]**
C. hirsuta Perr. & Guill., **C, [BK, HA]**
C. simensis Fresen., **C, [BK, BO, HA]**
Thalictrum rhynchocarpum Dill. & A. Rich., **H, [ALL]**
Ranunculus multifidus Forssk., **H, [BO, HA, YA]**

RHAMNACEAE Juss.
Gouania longispicata Engl. ,**C, [BK, BO, HA, YA]**
Helinus mystacinus (Ait.) E. Mey.ex Steud., **C, [BK, HA, YA]**
Rhamnus prinoides L´Herit. , **C, [BK, BO, HA, YA]**
R. staddo A. Rich. , **S, [BO}**
Sagetia thea (Osbeck) M.C.Johnston, **C, [HA]**
Scutia myrtina (Burm.f.) Kurz ,**C, [BK, HA]**
Ventilago diffusa (G.Don) Exell ,**C, [BK]**

RHIZOPHORACEAE R. Br.
Cassipourea malosana (Baker) Alston ,**MT, [ALL]**

ROSACEAE Juss.
Alchemilla fischeri Engl. ,**H, [BO]**
A. ellenbeckii Engl. , **H, [HA]**
Hagenia abyssinica (Bruce) J.F.Gmel. , **ST, [HA]**
Prunus africana (Hook.f.) Kalkm. , **TT, [BO, HA]**
Rosa abyssinica Lindley , **S, [HA]**
Rubus apetalus Poir. , **C, [ALL]**
R. rosifolius Sm. , **C, [BO]**
R. steudneri Schweinf. , **C, [BK, BO, HA, YA]**

RUBIACEAE Juss.
Breonadia salicina (Vahl) Hepper & Wood ,**MT, [HA, YA]**
Canthium oligocarpum Hiern, **ST, [BK, BO, HA, YA]**
Coffea arabica L. , **ST, [ALL]**
Craterispermum schweinfurthii Hiern , **S, [BK,]**
Crossopteryx febrifuga (Hochst.) Bridson , **ST, [BK, HA, YA]**
Hallea rubrostipulata (K. Schum.) J.F.Leroy , **ST, [BK]**
Hymenodictyon floribundum (Hochst. & Steud.) Rob., **ST, [BK]**
Galiniera saxifraga (Hochst.) Bridson, **ST, [BK, BO, HA, YA]**
Gardenia ternifolia Schumach. & Thonn., **ST, [BK, YA]**
Geophila repens (L.)J. M. Johnston , **H, [BK, BO, HA]**
Keetia gueinzii (Sond.) Bridson, **C, [BK, MA]**
K. zanzibarica (Klozsch) Bridson , **C, [BK]**
Mussaenda arcuata Poir. , **C, [BK]**
Oxyanthus speciosus ssp. globosus DC , **ST, [ALL]**
O. speciosus ssp. stenocarpus DC. , **ST, [BK]**
Pavetta oliveriana Hiern , **S, [BK, HA, MA]**
P. abyyssinica Fresen., **S, [BO, YA]**
Pentas schimperiana (A. Rich.) vatke , **H, [BO, HA]**
P. lanceolata (Forssk.) Defl., **H, [BO, HA, MA]**
Polysphaeria parvifolia Hiern, **S, [BK]**
Psychotria orophila Petit, **S, [BK, BO, HA, YA]**
P. peduncularis (Salisb.) Steyerm, **H, [BK, MA]**
Psydrax parviflora (Afz.) Bridson, **ST, [BK, MA, YA]**
P. schimperiana Spermacoce L., **ST, [HA]**
Rothmannia urceliformis (Hiern) Robyns, **ST, [BK, BO, MA]**
Rubia cordifolia L., **H, [BK]**
Rytigynia neglecta (Hiern) Robyns, **S, [ALL]**
Sarcocephalus latifolius (Smith) Bruce, **ST, [BK, HA, MA, YA]**
Spermacoce mauritiana Gideon, **S, [MA]**
Uncaria africana G. Don , **C, [BK, MA]**
Vangueria apiculata K. Schum., **ST, [BK]**
Wendlandia arabica Defl., **S, [BK]**

RUTACEAE Juss. .
Citrus aurantium L., **S, [HA]**
Clausena anisata (Willd.) Benth., **ST, [ALL]**
Fagaropsis angolensis (Engl.) Milne, **MT, [ALL]**
Teclea nobilis Del., **ST, [ALL]**
T. simplicifolia (Engl.) Verdoon, **ST, [HA, MA]**
Toddalia asiatica (L.) Lam., **C, [BK, HA, MA, YA]**
Vepris dainellii (Pichi-Serm.) Kokwaro,**ST, [ALL]**
Vepris sp., **ST, [BK]**
Zanthoxylum leprieurii Guill. & Perr., **ST, [BK]**

SAPINDACEAE Juss.
Allophylus abyssinicus (Hochst.) Radlkofer, **ST, [BO, HA]**
A. macrobotrys Gilg, **S, [BK, BO, MA]**
Blighia unijugata Bak., **MT, [BK, MA, YA]**
Cardiospermum halicacabun L., **C, [HA]**
Deinbollia kilimandscharica Taub , **ST, [BK, BO]**
Dodonaea angustifolia L.f. ,**ST, [HA, BO]**
Filicium decipiens (Wight & Am.) Thw. , **MT, [HA]**
Lecaniodiscus fraxinifolius Bak., **MT, [BK]**
Lepisanthes senegalensis (Juss. ex Poir.) Leenh., **ST, [BK]**
Pappea capensis Eckl. & Zeyh.,**ST, [YA]**
Paullinia pinnata L. ,**C, [BK, HA, MA, YA]**
Zanha golungensis Hiern, **MT, [BK]**

SAPOTACEAE Juss.
Manilkara butugi Chiov. , **TT, [BK, MA]**
Mimusops kummel A. DC. , **MT, [BK, HA, MA]**
Pouteria adolfi-friederici (Engl.) Baehni, **TT, [ALL]**
P. alnifolia (Bak.) Roberty, **MT, [BK]**
P. altissima (A.Chev.) Baehni, **TT, [BK, MA, YA]**

SCROPHULARIACEAE Juss.
Halleria lucida L., **S, [HA]**
Veronica abyssinica Fresen, **H, [HA]**

SIMAROUBACEAE DC.
Brucea antidysenterica J.F.Mill. , **ST, [ALL]**

SOLANACEAE Juss.
Capsicum frutescens L. , **H, [BK, BO]**
Datura stramonium L , **H, [BK, HA]**
Discopodium penninervium Hochst., **H, [BK, HA]**
Physalis peruviana L., **H, [BK, BO, HA, YA]**
Solanum benderianum L , **C, [BK, HA]**
S. giganteum L., **S, [HA]**
S. incanum L, **S, [BO, YA]**
S. indicum L., **S, [HA]**
S. nigrum L., **H, [BK, BO, YA]**

STERCULIACEAE Bartling
Dombeya torrida (J.F.Gmel.) P. Bamps, **ST, [BK, BO, HA]**

TACCACEAE L.
Tacca leontopetaloides (L.) O. Ktze., **H, [YA]**

TILIACEAE Juss.
Grewia ferruginea Hochst. Ex A. Rich, **S, [MA, YA]**
G. mollis A. Juss. , **S, [BK, HA]**
Triumfetta rhomboidea Jacq., **S, [BO, HA]**

ULMACEAE Mirbel
Celtis africana Burm.f., **MT, [ALL]**
C. gomphophylla Bak., **MT, [BK, BO, HA]**
C. philippensis Blanco, **MT, [BK, YA]**
C. toka (Forssk.) Hepper & Wood, **MT, [BK, YA]**
C. zenkeri Engl , **MT, [BK, YA]**
Trema orientalis (L.) Bl., **ST, [BK, HA, YA]**

URTICACEAE Juss.
Boehmeria macrophylla Homemann, **H, [HA]**
Droguetia iners (Forssk.) Schweinf., **H, [HA]**
Elatostema monticolum Hook.f., **H, [BO]**
Girardinia diversifolia (Link) Friis , **H, [BK, BO]**
Pilea tetraphylla 8Steudel) Blume , **H, [BK, HA]**
P. rivularis Wedd.H, **H, [BK]**
P. bambuseti Engl., **H, [BO]**
Urera hypselodendron (A. Rich.) Wedd. ,**C, [BK, BO, HA, YA]**
U. trinervis (Hochst.) Friis & Immelman , **C, [BK, YA]**
Urtica simensis Steudel ,**H, [HA]**

VERBENACEAE J.St. Hil.
Clerodendrum alatum L. , **S, [BO, YA]**
C. myricoides (Hochst.) Vatke, **S, [BO, HA]**
Premna schimperi Engl., **S, [HA]**

VIOLACEAE Batsch
Rinorea friisii M.Gilbert, **ST, [BK]**
R. ilicifolia (Oliv.)Kuntze , **S, [BK]**
VITACEAE Juss.
Ampelocissus abyssinica (Hochst.exA.Rich.)Planch, **C, [HA, MA]**
Cayratia gracilis (Guill. & Perr.) Suesseng., **C, [BO]**
Cissus arguta Hook.f., **C, [BK]**

C. petiolata Hook.f. , **C, [BO]**
C. quadrangulanis L. , **C, [BK, HA, YA]**
C. rotundifolia (Forssk.) Vahl , **C, [BK, HA]**
Cyphostemma adenocaule (Steud. ex A. Rich.) Descoings ex Wild & Drummond , **C, [ALL]**
C. kilimandscharica (Gilg)Descoing ex Wild & Drummond, **C, [ALL]**
Rhoicissius tridentata (L.f.) Wild & Drummond , **C, [HA, MA, YA]**

D.ANGIOSPERMAE-MONOCOTYLEDONAE

AMARYLLIDACEAE J. St. Hil.
Scadoxus multiflorus (Martyn) Raf., **H, [BK, BO, HA, YA]**
S. nutans (Friis & I. Bjørnstad) Friis & Nordal , **E, [BK, HA]**
S. puniceus (L.) Friis & Nordal, **H, [BK, BO]**

ANTHERICAEAE J. Agardh
Chlorophytum comosum (Thunb.)Jacq., **H, [BO]**
C. gallabatense Schweinf. ex Baker , **H, [BO]**
C. macrophyllum (A. Rich.) Aschers , **H, [BK, BO, HA, MA]**

ARACEAE Juss.
Culcasia falcifolia Engl. , **C, [BK, BO, MA, YA]**
Arisaema schimperannum Schott , **H, [BK, BO, HA, YA]**
A. flavum (Forssk.) Schott , **H, [BO]**
Amorphophallus abyssinicus (A. Rich.) N.E. Br. , **H, [BK, BO, HA]**
A. gallaensis (Engl.) N.E. Br, **H, [BO, YA]**

ARECACEAE Juss
Phoenix reclinata Jacq., **RT, [BK, BO, YA]**

ASPARAGACEAE Juss.
Asparagus africanus Lam., **C, [BK, YA]**
A. racemosus Willd. , **C, [BO, HA]**
A. officinalis L. , **C, [YA]**

COLCHICACEAE DC:
Gloriosa superba L. , **H, [BK, BO, YA]**

COMMELINACEAE R. Br.
Aneilema beniniense (P. Beauv.) Kunth , **H,[BK, BO, YA]**
Commelina cemosa Chiov. , **H, [BO, MA]**
C. foliacea Chiov. , **H, [BO, HA, YA]**
C. latifolia Hochst. ex A. Rich. , **H, [BK, YA]**
C. peterisii Hassk. , **H, [BO]**
C. diffusa Burm.f. , **H, [BK, HA]**
Pollia condensata C. B. Clarke, **H, [BK]**
P. mannii C. B. Clarke**, H, [BK, YA]**

COSTACEAE (K. Schum.) Nak.
Costus afer Ker-Gawl , **H, [BK]**
C. lucanusianus J. Braun & K. Schum , **H, [BK]**

CYPERACEAE Juss.
Carex echinochloe Kunze [1a-b], **G, [BO]**
Coleochloa abyssinica (Hochst. ex A.Rich.) Gilly, **G, [BK, BO]**
Cyperus aterrimus A. Rich. , **G, [BO]**
C. esculentus L., **G, [BO, HA, YA]**
C. fischerianus A. Rich. , **G, [BK, BO, HA]**
C. longibracteatus (Cherm.) Kuk , **G, [[BK]**
C. plateilma (Steud.) Kuk , **G, [HA]**
Cyperus rotundifolius L., G, [BK]

DIOSCOREACEAE R. Br.
Dioscorea bulbifera L., **C, [BK, YA]**
D. praehensilis Benth. , **C, [BK]**
D. sagittifolia Pax, **C, [BK]**
D. schimperiana Kunth , **C, [HA]**

DRACAENACEAE Salisb.
*Dracaena afromont*ana Mildbr., **RT, [BO, HA]**
D. fragrans (L.) Ker-Gawl, **RT, [All]**
D. steudneri Engler, **RT, [ALL}**

POACEAE Juss.
Arundo donax L., **S, [HA, YA]**
Digitaria abyssinica (Hochst. Ex A. Rich.) Stapf. **, G, [BO]**
Hyparrhenia cymbaria (L.) Stapf, **G, [BK]**
Leptaspis zeylanica Nees ex Steud., **G, [BK, YA]**
Olyra latifolia L. , **G, [BK, YA]**
Oplismenus compositus (L.) P. Beauv. , **G, [BO, HA]**
O. hirtellus (L.) P. Beauv. , **G, [ALL]**
O. undulatifolius (Ard.) Roem. & Schult., **G, [ALL]**
Panicum calvum Stapf, **G, [YA]**
P. repens L., **G, [BK]**
P. ruspolii Chiov. , **G, [BK]**
P. hochstetteri Steud. , **G, [YA]**
P. monticola Hook.f. , **G, [BO, HA]**
P. maximum Jacq., **G, [HA]**
P. porphyrrhizos Steud. , **G, [HA]**
*Pseudechinolaena polystachy*a *(*Kunth) Stapf. , **G, [HA]**
Poecilostachys oplismenoides(Hack.)W.D.Clayt, **G, [BO]**
Acritochaete volkensii Pilg. , **G, [BO]**
Pennisetum clandestinum Chiov. , **G, [HA]**
P. ramosum (Hochst.) Schweinf, **G, [HA]**
Poa leptoclada Hochst. ex A. Rich. , **G, [HA]**
Setaria atrata Hack., **G, [BK]**
S. megaphylla (Steud.)Th. Dur. , **G, [BK, BO, MA, YA]**
S. sphacelata (Schumach.) Moss , **G, [BK]**

HYACINTHACEAE Lindl.
Drimiopsis ?botryoides Baker., **H, [BK]**

MARANTACEAE Petersen
Marantochloa leucantha (K. schum.) Milne-Redh., **H, [BK]**
M. mannii (Bentham) Milne-Redh. , **H, [BK]**

MUSACEAE Juss.
Ensete ventricosum (Welw.) Cheesman, **RT, [BK]**

ORCHIDACEAE Juss.
Aerangis brachyarpa (A. Rich.) Th.Dur.& Schinz, **E, [BK,BO,MA,YA]**
A.luteoalba (Kraenzl.)Schltr.var.rhodostica (Kraenzl.) J.Stewart, **E, [BK, HA]**
A. thomsonii (Rolfe) Schltr , **E, [BK, YA]**
Ancistrorhynchus metteniae (Kraenzl.) Summerh, **E, [BK]**
Angraecum minus Summerh , **E, [BK]**
Bulbophyllum intertextum Lindl. , **E, [BK, HA]**
B. josephii (Kuntze) Summerh. , **E, [BK, YA]**
B. lupulinum Lindl. , **E, [BK, YA]**
B. scaberulum (Rolfe) Bolus , **E, [BK, HA, YA]**
Corymborkis corymbis Thouars , **H, [BK]**
Diaphananthe adoxa F. Rasm , **E, [BK, BO, HA]**
D.?fragrantissima (Rchb. f.)Schltr. , **E, [BK]**
D. tenuicalcar Summerh. , **E, [BO]**
Eulophia guineensis Lindl. **H, [BK, YA]**
Graphorkis lurida (Sw.) Kuntze, **H, [BK]**
Habenaria cornuta Lindl. , **H, [HA, YA]**
H. humilior Rchb.f., **H, [YA]**
H. malacophylla A.Rich. , **H, [BK, YA]**
H. peristyloides A. Rich. , **H, [YA]**
H. schimperiana A. Rich. , **H, [HA, YA]**
Liparis abyssinica A. Rich. , **H, [BO]**
L. deistelii Schltr. , **H, [BO]**
Malaxis weberbaueriana (Kraenzl.) Summerh , **H, [BO]**
Microcoelia globulosa (Hochst.) L. Johsson., **H, [YA]**
Nervilia bicarinata (Bl.)Schltr. , **H, [BK, YA]**
Oeceoclades ugande (Rolfe) Garay & Taylor, **H, [BK]**
Polystachya bennettiana Rchb. f. , **E, [BK, BO]**
P. caduca Rchb.f , **E, [BK, YA]**
P. cultriformis (Thouars)Spreng. , **E [BK, BO]**
P. lindblomii Schltr. , **E, [BK, BO]**
P. paniculata (Sw.) Rolfe , **E, [BK, YA]**
P. rivae Schweinf. , **E, [BK, HA]**
P. tessellata Lindl. , **E, [BK, HA]**
Satyrium schimperi A.rich. , **H, [HA]**
Stanfieldiella imperforata (C.B.Clarke)Brenan, **E, [BK]**
Stolzia repens (Rolfe) Summerh , **E, [BK]**
Tridactyle bicaudata (Lindl.) Schltr., [BK]
T. filifolia (Schltr.) Schltr , **E, [BK]**
Vanilla imperialis Kränzl. , **C, [BK}**

SMILACACEAE Vent.
Smilax anceps Willd., **C, [BK]**
S. aspera L., **C, [BK]**

ZINGIBERACEAE Lindl.
Aframomum corrorima (Braun) Jansen, **H, [BK, BO, YA]**
A. zambesiacum (Baker) K. Schum., **H, [BK]**
Curcuma domestica Valeton , **H, [BK]**
Zingiber officinale Roscoe, **H, [BK]**