

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

Feyera Senbeta<sup>1</sup>, Christine Schmitt<sup>2</sup>, Tadesse Woldemariam<sup>3</sup>, Hans Juergen Boehmer<sup>4</sup> and Manfred Denich<sup>5</sup>

<sup>1</sup> College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia

E-mail: feyeras@yahoo.com

<sup>2</sup> Institute for Landscape Management, University of Freiburg, Germany

<sup>3</sup> Environment and Coffee Forest Fourm, Ethiopia

<sup>4</sup> Interdisciplinary Latin America Centre, University of Bonn, Germany

<sup>5</sup> Centre for Development Research, University of Bonn, Germany

**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 Harena (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 Afromontane) 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 Woldemariam *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 Woldemariam *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 conservation 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, Hareenna, 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, Hareenna, Maji and Yayu forests (Fig. 1 and Table 1). Except for the Hareenna forest, which is located in the Eastern highland plateau,

all other forests are located on the Western highland plateau.

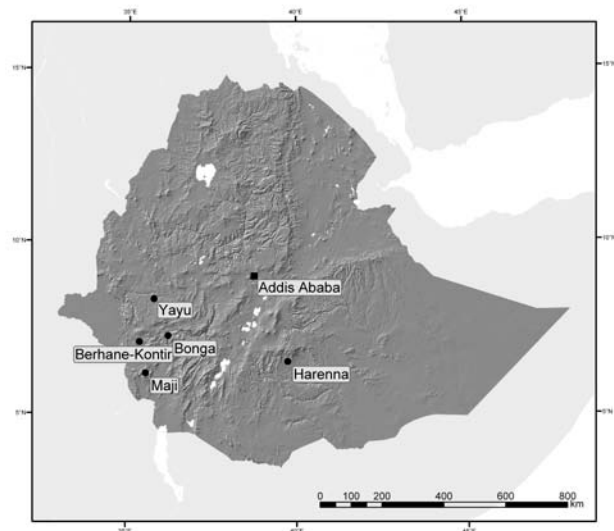


Figure 1. Map of Ethiopia showing the location of the study areas.

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 Hareenna 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 <sup>1</sup> (mm)	Tmin (°C)	Tmax (°C)	No. quadrats
Bonga	BO	1600–2300	5000	7° 08′	35° 53′	1718 <sup>(49)</sup>	12	26	28
Berhane-Kontir	BK	940–1800	10000	7°	35°	2200 <sup>(30)</sup>	15	29	37
Maji	MA	1600–1750	2000	6°	36°	1200 <sup>(23)</sup>	14	26	10
Yayu	YA	1200–2150	10000	8° 05′	35° 06′	1586 <sup>(20)</sup>	13	28	48
Hareenna	HA	1400–2000	15000	6°	40°	1000 <sup>(20)</sup>	10	28	24

<sup>1</sup> 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 Nitisols (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  $\alpha$  (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, Smilacaceae, Thelypteridaceae and Violaceae), seven were from Bonga (Aquifoliaceae, Chenopodiaceae, Marattiaceae,

Melastomataceae, Polygonaceae, Primulaceae and Vittariaceae), five were from Harena (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 Harena, 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 Harena and Bonga (SSC = 0.50), and Yayu and Bonga/Harena (0.42) forests, respectively.

#### *Alpha, beta and gamma diversity*

At the 400 m<sup>2</sup> 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  $\alpha$  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	Fabaceae	Orchidaceae	Euphorbiaceae	Rubiaceae	Fabaceae
Rubiaceae	32	Asteraceae	Rubiaceae	Rubiaceae	Fabaceae	Rubiaceae
Fabaceae	31	Orchidaceae	Euphorbiaceae	Orchidaceae	Euphorbiaceae	Orchidaceae
Asteraceae	30	Euphorbiaceae	Moraceae	Fabaceae	Celastraceae	Euphorbiaceae
Euphorbiaceae	29	Aspleniaceae	Acanthaceae	Moraceae	Rutaceae	Asteraceae
Acanthaceae	25	Rubiaceae	Fabaceae	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 > Hareenna > 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 Hareenna 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 environ-

mental 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 lowest and 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  $\geq 2$  cm dbh) were found in the lower diameter classes (Table 6). For example, 69 and 45% of the individuals in Bonga and Hareenna 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 Hareenna forest, respectively. The biggest diameter was recorded in the Hareenna 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 $\pm$ SE
Species richness per quadrat	66	45	46	37	30	44.8 $\pm$ 6.04
Fisher's $\alpha$	15.4	24.4	19.7	15.1	9.9	16.9 $\pm$ 2.43
Shannon diversity	3.17	2.83	2.60	1.54	2.8	2.58 $\pm$ 0.27
Shannon evenness	0.67	0.54	0.51	0.31	0.63	0.53 $\pm$ 0.06
Whittaker beta diversity	1.82	4.96	3.22	2.36	2.38	2.94 $\pm$ 0.55
Species turnover	1.86	6.48	3.27	2.22	2.65	3.29 $\pm$ 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 m<sup>2</sup> in the order of Berhane-Kontir > Maji > Harena > Bonga > Yayu (Table 6). The highest and lowest densities of woody plants were recorded in Yayu (69,130 individuals/ha) and Harena (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, Harena 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 dia-

gram 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 Yayu and Berhane-Kontir forests (Fig. 3).

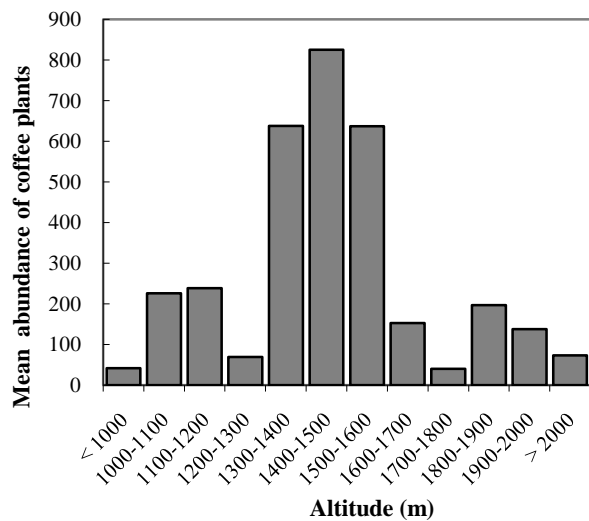


Figure 2. Mean abundance of wild coffee per quadrat along the altitudinal gradient in the studied Afromontane forests in Ethiopia.

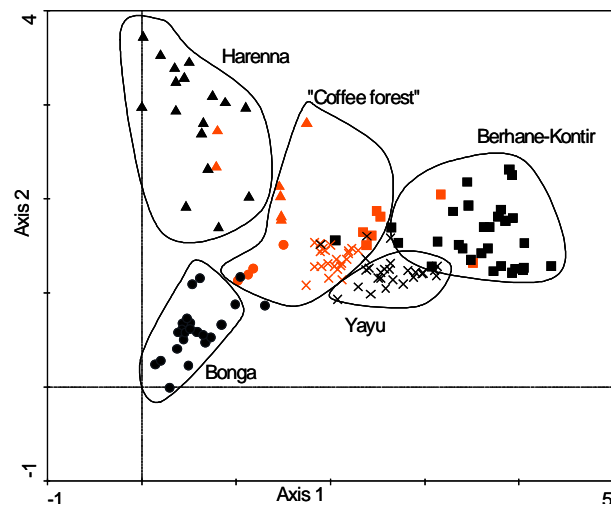


Figure 3. Ordination based on Detrended Correspondence Analysis (DCA) with abundance of woody species from four studied forests of Ethiopia (One symbol represents one site and the triangle represent the coffee populations).

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 <sup>2</sup> /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 (Tewelde-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 endemism 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 climatic 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 Harena 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 Hareenna 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 Hareenna 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 Hareenna 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 Hareenna 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 Hareenna 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 (Sarakinis *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, Hareenna 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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## REFERENCES

1. Austin, M.P., Pausas, J.G. and Nicholls, A.O. (1996). Patterns of tree species richness in relation to environment in south-eastern New South Wales Australia. *Aust. J. Ecol.* **21**:154–164.
2. Bone, L., Lawrence, M. and Magombo, Z. (1997). The effect of a *Eucalyptus camaldulensis* (Dehn) plantation on native woodland recovery on Ulumba Mountains, Southern Malawi. *Forest Ecol. Manag.* **99**:83–99.
3. Bonnefille, R. and Buchet, G., 1986. Forest history in Ethiopia, a pollen diagram from Wenchi. *SINET: Ethiop. J. Sci.* **9**:169–178.
4. Bonnefille, R. and Hamilton, A.C. (1986). Quaternary and late Tertiary history of Ethiopia Vegetation. *Symb. Bot. Ups.* **26**:48–63.
5. Bridgewater, S., Ratter, J.A. and Ribeiro, J.F. (2004). Biogeographic patterns,  $\beta$ -diversity and

- dominance in the cerrado biome of Brazil. *Biodiversity Conserv.* **13**:2295–2318.
6. Buckley, Y.M. and Kelly, C.K. (2003). Comparison of population structures and ecology of a congeneric pair of common and rare neotropical tree species. *Plant Ecol.* **167**:45–56.
  7. Cowling, R.M. (1990). Diversity components in a species-rich area of the Cape Floristic Region. *J. Veg. Sci.* **1**:699–710.
  8. Darbyshire, I., Lamb, H. and Umer, M. (2003). Forest clearance and regrowth in northern Ethiopia during the last 3000 years. *The Holocene* **13**:537–546.
  9. Demel Teketay (1999). History, botany and ecological requirements of coffee. *Walia* **20**:28–50.
  10. Dereje Tadesse, Tadesse Woldemariam and Feyera Senbeta (2008). Deforestation of Afromontane rainforests in Ethiopia In: *Deforestation Research Progress*, pp. 19–39, (Ilya B.S. and Carl L.A., ed), Nova Science Publishers, Inc.
  11. Edwards, S., Mesfin Tadesse and Hedberg, I. (1995). Flora of Ethiopia and Eritrea vol. **2**(2). The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  12. Edwards, S., Mesfin Tadesse, Sebsebe Demissew and Hedberg, I. (2000). Flora of Ethiopia and Eritrea, vol **2**(1). The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  13. Edwards, S., Sebsebe Demissew and Hedberg, I. (1997). Flora of Ethiopia and Eritrea vol. **6**. The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  14. Eklundh, L. (1996). AVHRR NDVI for monitoring and mapping of vegetation and drought in East African environments. Doctoral Dissertation, Lund University.
  15. Ewel, J. (1983). Succession. In: *Tropical rainforest ecosystems: structure and function*, pp. 9–26, (Golley G.B., ed), Ecosystems of the world 14A.
  16. EWNHS (1996). *Important Bird Areas of Ethiopia*. Ethiopian Wildlife and Natural History Society, Addis Ababa.
  17. Ferraz, E.M.N., Araújo, E.L. and da Silva, S.I. (2004). Floristic similarities between lowland and montane areas of Atlantic Coastal Forest in Northeastern Brazil. *Plant Ecol.* **174**: 59–70.
  18. Feyera Senbeta (2006). Biodiversity and ecology of montane rainforests with wild *Coffea arabica* L. populations in Ethiopia. *Ecology and Development Series 38*, Cuvillier Verlag, Göttingen.
  19. Feyera Senbeta and Denich, M. (2006). Effects of wild coffee management on species diversity in the montane rainforests of Ethiopia. *Forest Ecol. Manag.* **232**:68–74.
  20. Feyera Senbeta, Denich, M., Böhmer, H.J., Tadesse Woldemariam, Demel Teketay and Sebsebe Demissew (2007). Wild *Coffea arabica* L. in the Afromontane rainforests of Ethiopia: distribution, ecology and conservation. *SINET: Ethiop. J. Sci.* **30**(1):13–24.
  21. Feyera Senbeta, Schmitt, C., Denich, M., Sebsebe Demissew, Vlek, P.L.G., Preisinger H., Tadesse Woldemariam and Demel Teketay (2005). The diversity and distribution of lianas in the montane rainforests of Ethiopia. *Diversity Distrib.* **11**:443–452.
  22. Friis, I. (1992). Forests and forest trees of North East Tropical Africa. *Kew Bulletin Additional Series 15*, London.
  23. Friis, I., Edwards, S., Ensermu Kalbessa, and Sebsebe Demissew (2001). Diversity and Endemism in the Flora of Ethiopia and Eritrea-what do the published Flora volumes tell us? *Biol. Skr.* **54**:173–193.
  24. Friis, I., Rasmussen, F.N. and Vollesen, K. (1982). Studies on the flora and vegetation of Southwest Ethiopia. *Opera Botanic* **63**:1–70.
  25. Friis, I. and Sebsebe Demissew (2001). Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the flora of Ethiopia and Eritrea. *Biol. Skr.* **54**:399–439.
  26. Friis, I., Sebsebe Demissew and von Breugel, P. (2010). *Atlas of Potential Vegetation of Ethiopia*. The Royal Danish Academy of Science and Letters, Copenhagen.
  27. Gaston, K.J. (1994). *Rarity*. Chapman and Hall, London.
  28. Gentry, A.H. (1988). Changes in plant community diversity and floristic composition on environmental and Geographical gradients. *Ann. Miss. Bot. Gard.* **75**:1–34.
  29. Goldblatt, P. (1997). Floristic diversity in the Cape Flora of South Africa. *Biodiversity Conserv.* **6**:359–377.
  30. Halffter, G. (1998). A strategy for measuring landscape biodiversity. *Biol. Int.* **36**:3–17.
  31. Hamilton, A.C. (1975). A quantitative analysis of altitudinal zonation in Uganda forests. *Vegetatio* **30**: 99–106.
  32. Hedberg, I. and Edwards, S. (1989). Flora of Ethiopia and Eritrea vol. **3**. The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  33. Hedberg, I. and Edwards, S. (1995). Flora of Ethiopia and Eritrea vol. **7**. The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  34. Hedberg, I., Edwards, S. and Nemomissa, S. (2003). Flora of Ethiopia and Eritrea, vol **4**(1). The National Herbarium, Addis Ababa University,

- Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
35. Hedberg, I., Ensermu Kelbessa, Edwards, S., Sebsebe Demissew and Persson, E. (2006). Flora of Ethiopia and Eritrea, vol 5. The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  36. Hedberg, I., Friis, I. and Persson, E. (EDs.). (2009). Flora of Ethiopia and Eritrea, vol. 1. The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  37. Hedberg, I., Friis, I. and Edwards, S. (2004). Flora of Ethiopia and Eritrea, vol 4(2). The National Herbarium, Addis Ababa University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala.
  38. Hedberg, O. (1964). Features of Afroalpine plant ecology. *Acta Phytogeography Suec.* **49**:1-144.
  39. Hill, M.O. and Gauch, H.G. (1980). Detrended correspondence analysis: an improved ordination technique. *Vegetatio* **42**:47-58.
  40. Körner, C. (2000). Why are there global gradients in species richness? Mountains may hold the answer. *Trends Ecol. Evol.* **15**:513-514.
  41. Lima, S.L. and Zollner, P.A. (1996). Towards a behavioral ecology of ecological landscapes. *Trends Ecol. Evol.* **11**:131-135.
  42. Lisanework Nigatu and Mesfin Tadesse (1989). An ecological study of the vegetation of the Hareenna forest, Bale, Ethiopia. *SINET: Ethiop. J. Sci.* **12**(1):63-93.
  43. Logan, W.E.M. (1946). An introduction to the forests of central and southern Ethiopia. *Imperial Forestry Institute Paper* **24**:1-58.
  44. Lovett, J.C., Rudd, S., Aplin, J. and Frimodt-Moller, C. (2000). Patterns of plant diversity in Africa south of the Sahara and their implications for conservation management. *Biodiversity Conserv.* **9**:37-46.
  45. MacArthur, R.H. (1972). *Geographical Ecology*. Harper and Row, New York.
  46. Maestre, F.T. (2004). On the importance of patch attributes, environmental factors and past human impacts as determinants of perennial plant species richness and diversity in Mediterranean Semiarid Steppes. *Diversity Distrib* **10**:21-29.
  47. Magurran, A.E. (1988). *Ecological diversity and its measurement*. Chapman and Hall.
  48. McAleece, N. (1997). *BioDiversity Professional Beta version*. The Natural History Museum and Scottish Association for Marine Science.
  49. McCune, B. and Grace, J.B. (2002). *Analysis of Ecological Communities*. MjM Software Design, USA.
  50. Mesfin Tadesse and Lisanework Nigatu (1996). An ecological and ethnobotanical study of wild or spontaneous coffee, *Coffea arabica* in Ethiopia. **In: The biodiversity of African Plants**, pp. 277-294, (Van der Maesen, L.J.G., van der Burgt, X.M., and van Medenbach de Rooy. J.M., eds), Academic Publishers, Dordrecht.
  51. Moreno, C.E. and Halffter, G. (2001). Spatial and temporal analysis of  $\alpha$ ,  $\beta$  and  $\gamma$  diversities of bats in a fragmented landscape. *Biodiversity Conserv.* **10**:367-382.
  52. Murphy, H.E. (1968). *A Report on the Fertility Status and other Data on some Soils of Ethiopia*. College of Agriculture, Dire Dawa.
  53. Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* **403**:853-858.
  54. NMA (2002). *Climatic data*. National Meteorological Service Agency, Addis Ababa, Ethiopia.
  55. Perlman, D.L. and Adelson, G. (1997). *Biodiversity: exploring values and priorities in conservation*. Blackwell Science.
  56. Petraitis, P., Latham, R. and Niesenbaum, R. (1989). The maintenance of species diversity by disturbance. *Quart. Rev. Biol.* **64**:393-418.
  57. Phillips, O.L., Hall, P., Gentry, A.H., Sawyer, S.A. and Vasquez, R. (1994). Dynamics and species richness of tropical rain forests. *Proceedings of the National Academy of Science*. **91**:2805-2809.
  58. Reusing, M. (2000). Change detection of Natural High Forests in Ethiopia Using Remote Sensing and GIS Techniques. *IAPRS* **33**:1-25.
  59. Sarakinos, H., Nicholl, A.O., Tubert, A., Aggarwal, A., Margules, C.R. and Sarkar S. (2001). Area prioritization for biodiversity conservation in Québec on the basis of species distributions: a preliminary analysis. *Biodiversity Conserv.* **10**:1419-1472.
  60. Shmida, A. and Wilson, M.V. (1985). Biological determinants of species diversity. *J. Biogeogr.* **12**:1-20.
  61. Tadesse Woldemariam (2003). Vegetation of the Yayu forest in sw Ethiopia: impacts of human use and implications for in situ conservation of wild *Coffea arabica* L. populations. *Ecology and Development Series 10*, Cuvillier Verlag, Gottingen.
  62. Tadesse Woldemariam, Borsch, T., Denich, M. and Demel Teketay (2008). Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. *Forest Ecology and Management* **255**:2138-2150.
  63. Tadesse Woldemariam, Denich M., Demel Teketay and Vlek, P.L.G. (2002). Human impacts on *Coffea arabica* gene pool in Ethiopia and the need for its *in situ* conservation. **In: Managing Plant Genetic Diversity**, pp. 237-247, (Engels, J., Ramanatha Rao, V., Brown, A.H.D. and Jackson, M., eds.). CAB International, Oxon.
  64. Tafesse Asres (1996). Agroecological Zones of Southwest Ethiopia. *Doctoral thesis*, University of Trier.

65. Tamrat Bekele (1994). Studies on remnant montane forests on the central plateau of Shewa, Ethiopia. *Acta Phytogeogr. Suec.* **79**:1-58.
66. Tewolde-Berhan G/Egziabher (1991). Diversity of the Ethiopian Flora. In: Plant Genetic Resources of Ethiopia, pp. 75-81, (Engles, J.M.M., Hawkes, J.G. and Melaku Worede, eds.). Cambridge University Press, Cambridge.
67. Ter Braak, J.C. (2003). Canoco for Windows 4.5 (c) 1997-2002; *Biometris- quantitative methods in the life and earth sciences*. Plant Research International, Wageningen University and Research Centre, the Netherlands.
68. Urban, D.L., O'Neill, R.V. and Shugart, L. (1987). Landscape ecology. *BioScience* **37**:119-127.
69. Urban, D.L., Miller, C., Halpin, P.N. and Stephenson, N.L. (2000). Forest gradient response in Sierran landscapes: the physical template. *Landscape Ecol.* **15**:603-620.
70. Valencia, R. (1995). Composition and structure of an Andes forest fragment in eastern Ecuador. In: *Biodiversity and Conservation of Neotropical Montane Forests*, pp. 239-249, (Churchill, S.P. et al., eds), The New York Botanic Garden.
71. Von Breitenbach, F. (1961). Forests and woodlands of Ethiopia: a geobotanical contribution to the knowledge of the principal plant communities of Ethiopia, with special regard to forestry. *Ethiopian Forestry Review* **1**:5-10.
72. Vuilleumier, F. and Simberloff, D. (1980). Ecology versus history as determinants of patchy and insular distribution in high Andean birds. *Evol. Boil.* **12**:235-379.
73. White, F. (1978). The Montane Region. In: *Biogeography and ecology of Southern Africa*, pp. 463-513, (Werger, M.J.A., ed.), Junk, The Hague.
74. White, F. (1983). *The Vegetation of Africa. A Descriptive Memoir to Accompany the Unesco/AETFAT/UNSO Vegetation Map of Africa*. UNESCO, Paris.
75. Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon* **21**:213-251.
76. Wilson, M.V. and Shmida A. (1984). Measuring beta diversity with presence-absence data. *J. Ecol.* **72**:1055-1064.
77. Wolf, J.H.D. (1994). Factors controlling the distribution of vascular and non-vascular epiphytes in the northern Andes. *Vegetatio* **112**:15-28.

**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). Presence of species in each study site is indicated by tallying study forest (s) as [BK-Berhane-Kontir; BO-Bonga; HA-Hareenna; 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* Alston, E, [HA]  
*Polystichum transoalense* 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. inaequilaterale* 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 schimperii* 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

- Elaphoglossum 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]  
*Platyterium 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. forskoalii* (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. diclipterooides* Lindau, H, [BK, BO]

*J. flava* (Forssk.) Vahl, H, [BK]

*J. glabra* Roxb., H, [BO, MA, YA]

*J. heterocarpa* T. Anderson, H, [YA]

*J. schimperi* (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]

*Phayloopsis 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 cylindrica* Moq., H, [BO, HA]

*C. uncinulata* (Schr.) Schinz, H, [BK, BO, MA]

*Gomphosiphon celosioideus* 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. quartiniiana* 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]

*Xylopiopsis parviflora* (A. Rich.) Benth., 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]

*Pentstemon nivalis* D.V. Field & J.R.I. Wood, C, [BK]

*Pentstemon insipidus* 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 mauritanium* DC, H, [BK, BO]

*Ageratum conyzoides* L., H, [BK, BO, HA, YA]

*Aspilula 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 Oliv., 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. hochstetteri* 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]

**CANELACEAE 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. petitiiana* 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* Schumacher, 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.) Jeffrey, 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. fruticosa* 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]  
*Erythrocoeca 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]  
*Calpurnia 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]  
*Milletia ferruginea* (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 schimperii* (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. lamifolium* Hochst. ex Benth., **S**, [BO, HA, MA, YA]  
*Plectranthus punctatus* (L.f.) L'Her, **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 stellerioides* (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 hemingsii* Gilg, **ST**, [BK, HA]  
*S. innocua* Del., **ST**, [BK]  
*S. mitis* S. Moore, **MT**, [BK, HA, MA]

**MALVACEAE Juss.**

*Abutilon ceciliae* 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 mauritanium* J.F.Gmel., **H**, [BO]

**MELIACEAE Juss.**

*Ekebergia capensis* Sparrm., **MT**, [BK, BO, HA, YA]  
*Lepidotrichilia volkensii* (Gurke) Leroy, **ST**, [ALL]  
*Pseudoedrela kotschyii* (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 soerenseii* Friis, **H**, [BK, BO]  
*D. barnimiana* Schweinf., **H**, [BK, BO]  
*Ficus asperifolia* Miq., **ST**, [BK]  
*F. capraefolia* Del., **ST**, [YA]  
*F. exasperata* Vahl., **ST**, [BK, HA, YA]  
*F. lutea* Vahl., **ST**, [BK, MA, YA]  
*F. mucosa* 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 schimperii* 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. **OLivicolture**, **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 Valetton**

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

**OXALIDACEAE R. Br.**

*Oxalis corniculata* L., **H**, [BO]  
*O. radicata* 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.**

*Hillieria 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* Schumacher & Thonn., ST, [BK, YA]  
*Geophila repens* (L.) M. Johnston, H, [BK, BO, HA]  
*Keetia queinzii* (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. abyssinica* 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.) Steyerl., H, [BK, MA]  
*Psydrax parviflora* (Afz.) Bridson, ST, [BK, MA, YA]  
*P. schimperiana* Spermaceo L., ST, [HA]  
*Rothmannia urceoliformis* (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]  
*Spermaceo 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 lepreurii* 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 halicacabum* 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]  
*Pappaea 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 adolphi-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 penninerviium* 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* (Steudel) Blume, H, [BK, HA]  
*P. rivularis* Wedd., 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 schimperii* Engl., S, [HA]

**VIOLACEAE Batsch**

- Rinorea friisii* M. Gilbert, ST, [BK]  
*R. ilicifolia* (Oliv.) Kuntze, S, [BK]

**VITACEAE Juss.**

- Ampelocissus abyssinica* (Hochst. ex A. 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. quadrangulans* L. , C, [BK, HA, YA]  
*C. rotundifolia* (Forssk.) Vahl , C, [BK, HA]  
*Cyphostemma adenocaula* (Steud. ex A. Rich.) Descouings ex Wild & Drummond , C, [ALL]  
*C. kilimandscharica* (Gilg) Descouing ex Wild & Drummond, C, [ALL]  
*Rhoicissus tridentata* (L.f.) Wild & Drummond , C, [HA, MA, YA]

#### **D.ANGIOSPERMAE-MONOCOTYLEDONAE**

##### **AMARYLLIDACEAE J. St. Hil.**

*Scadoxus multiflorus* (Marty) 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 schimperianum* 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 cernua* 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]  
*Polia 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 echinoclhoe* 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 afromontana* 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 polystachya* (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]  
*Diaphanthe 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. peristylodes* 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]  
*Neroilia 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 schimperii* A. Rich. , H, [HA]  
*Stanfieldiella imperforata* (C.B. Clarke) Brennan, 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. zambesiicum* (Baker) K. Schum., H, [BK]  
*Curcuma domestica* Valetton , H, [BK]  
*Zingiber officinale* Roscoe, H, [BK]