# ORIGINAL ARTICLE

# Plant Species Richness and Diversity in Beda-Buna Coffee Forest, Jimma Zone, Oromia Regional State, Southwest Ethiopia

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**ABSTRACT**
Traditional coffee management system in Ethiopia has contributed to the conservation of canopy trees and fragmented forest patches in the Jimma Highlands. This study was conducted on Beda-Buna coffee forest in Jimma Zone, southwest Ethiopia. The objective of this study was to determine plant species richness, woody species diversity and abundance. Thirty-one sampling plots of 20×20m were placed systematically along two transects. Overall, 80 species of vascular plants belonging to 72 genera and 43 families were identified and recorded. The forest is characterized by high basal area, low adult tree densities and poor seedling and sapling densities. The presence of coffee has contributed to the persistence of this forest patch and the ownership type also contributed to the high density of some plant species. To make this coffee forest sustainable, care should be taken for seedlings and saplings of the tree species when clearing the ground cover for better yield of coffee. Leaving some strips of land between consecutive coffee plots would help the conservation of lianas and other tree species which would otherwise be at risk of local extinction.

**Keywords:** Beda-Buna; Jimma highlands; Kersa district; Semi forest coffee; Species richness

## INTRODUCTION

Coffee agroforestry in Ethiopia is one of the agricultural practices implemented under different management regimes. Four different coffee management systems are practiced in Ethiopia: semi-forest coffee, wild coffee, garden coffee and plantation coffee systems (Teketay, 1999). Coffee grown under shade trees supports biodiversity conservation (Perfecto and Armbrecht, 2002; Denu *et al.*, 2016). Shade coffee system is friendly practice for forest conservation and related fauna (Perfecto and Armbrecht, 2002; Rappole *et al.*, 2003; Dietsch *et al.*, 2004; Tejeda-Cruz and Sutherland, 2004; Raman, 2006; Conservation International, 2008). Shade coffee system sustains a high species diversity of plants and animals (Perfecto *et* *al.*, 1996; Moguel and Toledo, 1999; Perfecto and Armbrecht, 2002). The traditional coffee growing method in Ethiopia supported the preservation of indigenous forest cover while other land use systems around the coffee farm reduced the canopy cover (Aerts *et al.,* 2011; Denu *et al*., 2016). It can be obviously deduced that coffee has contributed for the existence of small forest patches observed in southwest Ethiopia to which our study area belongs. According to Aerts *et al.* (2011), the climax forest tree species are underrepresented in the canopy of semi-forest coffee fragments. People selectively maintain trees that could suit for coffee management (Denu *et al*., 2016). As it was indicated by Aerts *et al.* (2011), traditional coffee cultivation in southwest Ethiopia is characterized by few stems, low canopy height and low crown closure of the tree species (Aerts *et al*., 2011). Application of good management practices could help to maintain the remaining climax species in the SFC systems in southwest Ethiopia (Aerts *et al*., 2011). Forest and semi-forest coffee systems in southwest Ethiopia are conservation oriented (Hylander and Nemomissa, 2008; Denu *et al*., 2016). Similar situations have been observed in other parts of the world (Bandeira *et al*., 2005; Gordon *et al*., 2007; Ambinakudige and Sathish, 2009).

The moist montane forests of southwest Ethiopia are home for wild *Coffea arabica* which Ethiopia has contributed to the world. Most of the remnant forests of Ethiopia are found in this part of the country. Small forest patches in Jimma highlands are mostly small holder coffee systems and the trees are used for protecting the coffee from direct sun. The shade trees like *Acacia abyssinica*, *Albizia gummifera* and *Cordia africana* are selectively retained in the coffee farm (Muleta *et al*., 2011; Denu *et al*., 2016; Hundera, 2016). Beda-Buna semi-forest coffee (hereafter referred to as Beda-Buna coffee forest) is a patch of canopy trees protected for shade provision for the coffee shrubs. So far, there has not been any research work on the plant species richness, woody species diversity and abundance in Beda-Buna coffee forest, and hence this study was conducted to fill the existing knowledge gap.

## MATERIALS AND METHODS

### Study area

Beda-Buna coffee forest is located near Jimma town in Kersa District, Jimma Zone, Oromia Regional State, southwest Ethiopia (Figure 1). It is within the Eastern Arc Afromontane Biodiversity Hotspot area in Ethiopia (Mittermeier *et al*., 2004). The District is located in the altitudinal range of 1740–2660 m above sea level. The high peaks in the district include Gora, Folla, Kero, Sume and Jiren mountain chains. Land inventory in the district indicated that the arable land is 58.6% (about 37.5% is occupied by annual crops), the land dedicated for pasture is 17.3% and forest occupied 6% and the remaining 18.9% is swampy (KDLSWMB, 2017). Coffee production is the most important cash crop in the District and more than 50 km$^2$ of land is dedicated for coffee planting (KDLSWMB, 2017).

Based on the climate data from 2005-2015 (NMA, 2018), the average maximum and minimum temperature were 30°C and 7.4°C respectively (Figure 2). The sum of average precipitation is 1577 mm. The study area is characterized by humid, per-humid and dry conditions (Figure 2). The dry condition prevails in the month of February and to a lesser extent in December (Figure2).

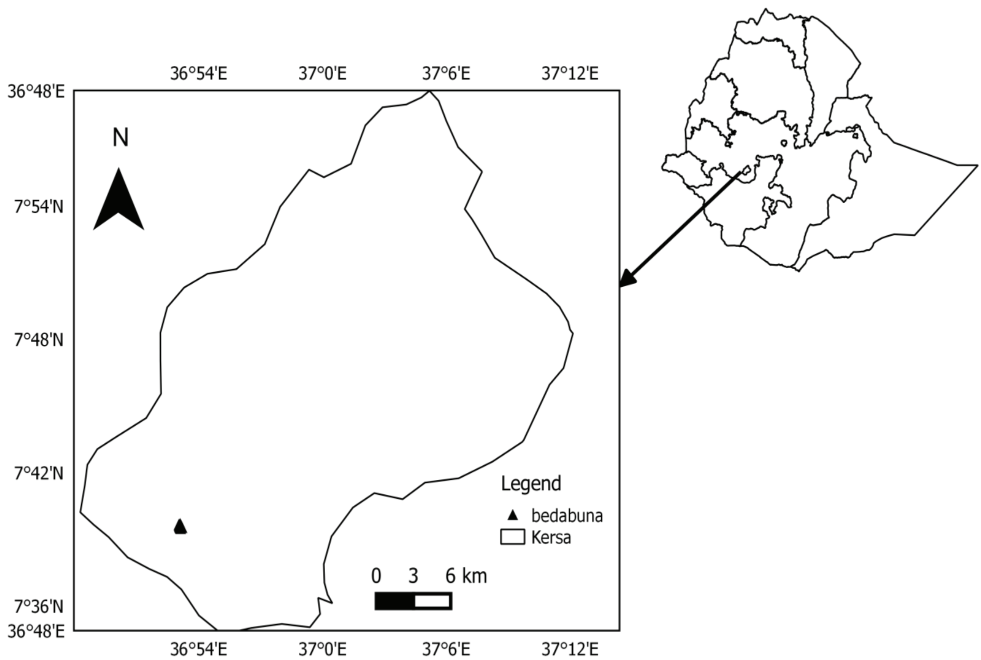



**Figure 1.** Map of study area (Kersa District), Jimma Zone, southwest Ethiopia

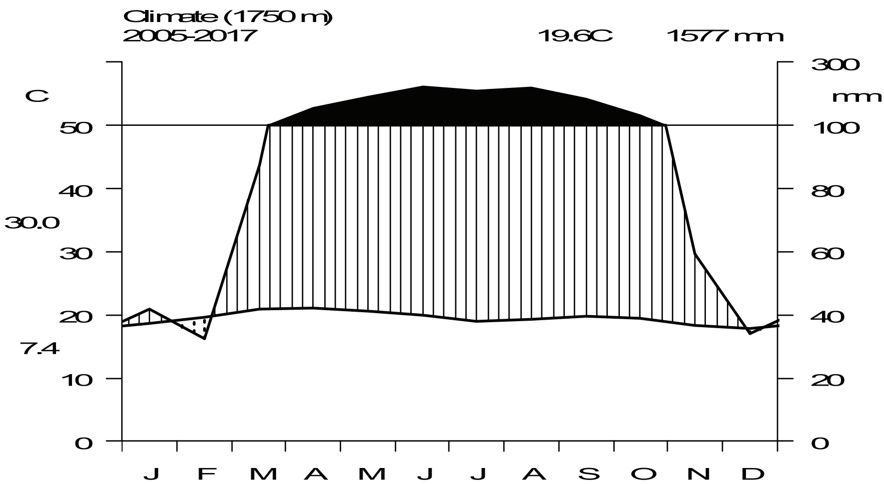



**Figure 2.** Climate diagram of the study area (Jima station), southwest Ethiopia

**Study design**

This study was conducted from September 4 to 14, 2012. Reconnaissance survey was carried out one week before the actual field work. This was used to get information on the site condition of the study forest and to decide where to place the transect lines for the actual field data collection. Based on the information obtained during the reconnaissance survey, two transect lines were placed at a distance of 500 m from each other. Thirty-one plots of 20×20m were laid at 20m interval along two transects in Beda-Buna coffee forest. Subplots of 5 × 5m and 1×1m were laid at the corners and the center of the larger (20×20m) plots.

**Data collection**

Data on woody species were recorded from 20×20m plots. To reduce the chance of missing small herbs, data were collected from 1×1m subplots, while the seedlings and saplings of woody species were recorded from 5×5m plots. Published volumes of Flora of Ethiopia and Eritrea were used for the identification of plant species.

**Data analysis**

**Species diversity**

Species diversity was analyzed using Shannon-Wiener Diversity index (Shannon, 1949) from PAST free software (Hammer *et al*., 2005).

$H = -\sum P_i \ln P_i$,

Where, H = Shannon and Wiener diversity index, Pi = the ratio of a species average to the total species average; ln = the natural logarithm to base e ($\log_e$)

The species evenness was calculated from the following formula

$$\mathbf{J = H/H_{max}}$$

Where,

J = the species evenness; $H_{max}$ = lnS, where "S" stands for the number of species

**Vegetation structure**

Diameter of trees and shrub species was calculated from circumference measurement of each individual woody species using the following formula.

$$d = C/\pi$$

Woody species basal area (BA) was directly calculated from the circumference (C) measurement using the following formula.

$$BA = \pi(C/2\pi)^2$$

The basal area of each woody species was calculated by adding the basal areas of individual trees belonging to the species in the sample area. The density of plant species in the study forest was assessed and determined. Density refers to the number of individual plants of a certain species per unit area. It is closely related to abundance but more useful in estimating the importance of a species.

**Importance value index**

Importance value index (IVI) is a measure of species composition that combines abundance, frequency and dominance of woody species. It was calculated from the following formula (Husch et al., 2003):

$$Ij = 100\left(\frac{nj}{N} + \frac{dj}{D} + \frac{xj}{X}\right)$$

$I_j$ = importance value of the $j^{th}$ species,
$n_j$ = the plots in which the $j^{th}$ species occur,
N = total number of sampling plots,
$d_j$ = number of individuals of the $j^{th}$ species present in sample population,
D = total number of individuals in sample population,
$x_j$ = sum of size parameters (basal area) for the $j^{th}$ species,
$X = \sum x_j$

## RESULT

**Species area curve**

Species area curve (Figure 3) shows a good sampling effort.

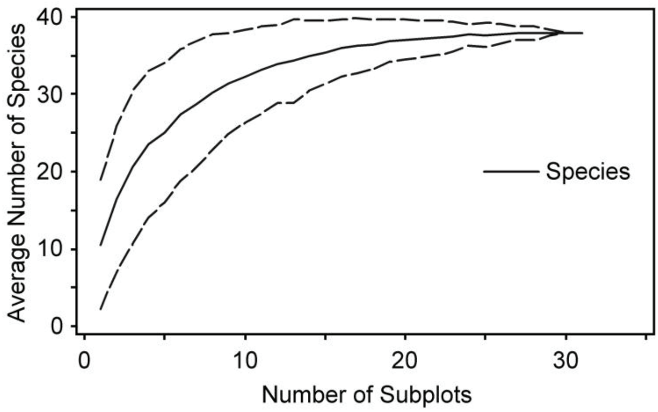



**Figure 3.** Species area curve of Beda-Buna semi-forest coffee showing the sampling effort

**Plant species richness**

A total of 80 vascular plant species belonging to 72 genera and 44 families were identified and recorded (Table 1). The top three species rich families were Euphorbiaceae (9 species), Fabaceae (8 species) and Asteraceae (6 species). Rubiaceae was composed of 4 species, Oleaceae and Moraceae composed of 3 species each, Acanthaceae, Boraginaceae, Celastraceae, Myrtaceae, Piperaceae, Poaceae, Rosaceae and Solanaceae were composed of 2 species each, while each of the remaining families was represented by one species. The genus *Ficus* was represented by 3 species and *Desmodium*, *Olea*, *Peperomia*, *Phyllanthus*, *Rubus* and *Vernonia* were represented by 2 species each. The remaining genera were represented by one species each. Regarding the growth form distribution of plant species in Beda-Buna coffee forest, trees represent 29%, shrubs 25%, herbs 40% and liana 6% of the total collection. In general, the woody species (trees + shrubs+ liana growth forms) together contributed 60%, while the contribution of non-woody vascular plants to the total collection was 40%.

The rank abundance increased with decreasing number of individuals of the species. The species with the highest number of individuals ranked first while the species with the least number of individuals ranked last. In this study, the highest number of individuals/ha (number of stems = 218, relative abundance = 0.260) was recorded for *Calpurnia aurea* while the least (number of stems = 2, relative abundance = 0.002) was recorded for Ekebergia *capensis*. The five top abundant species were *Calpurnia aurea* (relative abundance = 0.26), *Diospyros abyssinica* (relative abundance = 0.103), *Cordia africana* (relative abundance = 0.082), *Albizia gummifera* (relative abundance = 0.074), *Maesa lanceolata* (relative abundance = 0.057). The five least abundant species were *Ekebergia capensis* (relative abundance = 0.002) *Apodytes dimidiata* (relative abundance = 0.004), *Maytenus arbutifolia*, *Rothmannia urcelliformis*, *Vernonia auriculifera*, *Dalbergia lacteal*, *Millettia ferruginea* and *Psidium guajava*, each of them with relative abundance of 0.005. The relative abundance is given on the Y-axis on the log scale (Figure 4). The relative abundance shows the number of individuals of one species relative to the sum of abundances of all species in the sample population.

**Table 1.** List of plant species recorded from Beda-Buna coffee forest, Jimma Zone, Southwest Ethiopia

| Species name | Family |
|---|---|
| *Acalypha racemosa* Baill. | Euphorbiaceae |
| *Acanthus eminens* C.B.Clarke | Acanthaceae |
| *Adiantum raddianum* C Presl. | Adiantaceae |
| *Ageratum conyzoides* subsp. *Conyzoides* | Asteraceae |
| *Ajuga sp.* | Lamiaceae |
| *Albizia gummifera* (J.F. Gmel.) C.A. Sm. | Fabaceae |
| *Alchemilla abyssinica* Fresen. | Rosaceae |
| *Allophylus macrobotrys* Gilg. | Sapindaceae |
| *Amorphophallus gallaensis* (Engl.) N.E.Br. | Araceae |
| *Apodytes dimidiata* E. Mey. ex Arn. | Icacinaceae |
| *Asparagus racemosus* Willd. | Asparagaceae |
| *Bersama abyssinica* Fresen. | Melianthaceae |
| *Bidens pilosa* L. | Asteraceae |
| *Calpurnia aurea* (Ait.)Benth. | Fabaceae |
| *Canthium oligocarpum* Hiern. | Rubiaceae |
| *Celtis africana* Burm.f. | Ulmaceae |
| *Clausena anisata* (Willd.) Benth. | Rutaceae |
| *Clematis hirsuta* Perr. & Guill. | Ranunculaceae |
| *Clutia lanceolata* Forssk. | Euphorbiaceae |
| *Combretum paniculatum* Vent. | Combretaceae |
| *Commelina benghalensis* L. | Commelinaceae |
| *Cordia africana* Lam. | Boraginaceae |
| *Croton macrostachyus* Del. | Euphorbiaceae |
| *Cyperus bulbosus* Vahl. | Cyperaceae |
| *Cyphostemma adenocaule* (Steud.ex A.Rich.) Desc.ex Wild & Drummond | Vitaceae |
| *Dalbergia lactea* Vatke | Fabaceae |
| *Desmodium repandum* (Vahl) DC. | Fabaceae |
| *Desmodium uncinatum* (Jacq.)DC. | Fabaceae |
| *Dioscorea bulbifera* L. | Dioscoriaceae |
| *Diospyros abyssinica* ( Hiern) F. White | Ebenaceae |

| Species name | Family |
|---|---|
| *Doryopteris concolor* (Langsd. & Fisch.) Kuhn | Sinopteridaceae |
| *Dracaena steudneri* Engl. | Dracaenaceae |
| *Drynaria volkensii* Hiern. | Polypodiaceae |
| *Dryopteris schimperiana* (Hochst.ex A.Br.) C.Chr. | Dryopteridaceae |
| *Ehretia cymosa* Thonn. | Boraginaceae |
| *Ekebergia capensis* Sparrm. | Meliaceae |
| *Erythrococca trichogyne* (Muell.Arg.) Prain | Euphorbiaceae |
| *Euphorbia schimperiana* Scheele | Euphorbiaceae |
| *Ficus sur* Forssk. | Moraceae |
| *Ficus thonningii* Blume | Moraceae |
| *Ficus vasta* Forssk. | Moraceae |
| *Galinsoga parviflora* Cav. | Asteraceae |
| *Helinus mystacinus* (Ait.) E.Mey.ex Steud. | Rhamnaceae |
| *Hippocratea goetzei* Loes. | Celastraceae |
| *Impatiens ethiopica* Grey- Wilson. | Balsaminaceae |
| *Jasminum abyssinicum* Hochst.ex DC. | Oleaceae |
| *Justicia schimperiana* (Hochst. ex Nees) T. Anders. | Acanthaceae |
| *Kalanchoe laciniata* (L) DC. | Crassulaceae |
| *Laggera alata* (D. Don) Sch. Bip. exOliv. | Asteraceae |
| *Maesa lanceolata* Forssk. | Myrsinaceae |
| *Maytenus arbutifolia* (A.Rich.) Wilczek. | Celastraceae |
| *Millettia ferruginea* (Hochst.) Bak. | Fabaceae |
| *Momordica foetida* Schumach. | Cucurbitaceae |
| *Olea capensis* L. | Oleaceae |
| *Olea welwitschii* (Knobl.) Gilg & Schellenb. | Oleaceae |
| *Oplismenus compositus* (L.) P. Beauv | Poaceae |
| *Pentas lanceolata* (Forssk.) Deflers | Rubiaceae |
| *Peperomia abyssinica* Miq. | Piperaceae |
| *Peperomia tetraphylla* (Forster.) Hook. & Arn. | Piperaceae |
| *Phoenix reclinata* Jacq. | Arecaceae |
| *Phyllanthus limmuensis* Cufod. | Euphorbiaceae |
| *Phyllanthus mooneyi* M.Gilbert | Euphorbiaceae |
| *Physalis peruviana* L. | Solanaceae |
| *Psidium guajava* L. | Myrtaceae |

| Species name | Family |
|---|---|
| *Pterolobium stellatum* (Forsk.)Brenan | Fabaceae |
| *Ritchiea albersii* Gilg. | Capparidaceae |
| *Rothmannia urcelliformis* (Hiern) Robyns | Rubiaceae |
| *Rubus apetalus* Poir | Rosaceae |
| *Rubus steudneri* Schweinf. | Rosaceae |
| *Sapium ellipticum* (Krauss) Pax | Euphorbiaceae |
| *Schefflera abyssinica* (Hochst. ex A. Rich.) Harms | Araliaceae |
| *Senna petersiana* (Bolle) Lock. | Fabaceae |
| *Setaria megaphylla* (Steud.) Th. Dur. & Schinz | Poaceae |
| *Solanum giganteum* Jacq. | Solanaceae |
| *Syzygium guineense* (Willd.) DC | Myrtaceae |
| *Thalictrum rhynchocarpum* Dill. & A. Rich. | Rhamnaceae |
| *Tragia brevipes* Pax | Euphorbiaceae |
| *Triumfetta rhomboidea* Jacq. | Tiliaceae |
| *Vernonia auriculifera* Hiern. | Asteraceae |
| *Vernonia biafrae* Oliv.&Hiern | Asteraceae |

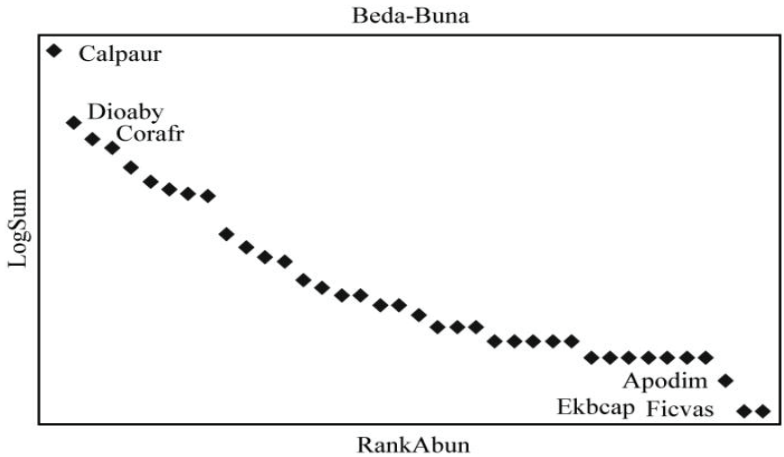



**Figure 4.** Rank abundance curve of the study area (Calaur= *Calpurnia aurea,* Dioaby = *Diospyros abyssinica,* Corafr = *Cordia africana,* Albgum =*Albizia gummifera,* Maelan = *Maesa lanceolata,* Millfer = *Millettia ferruginea,* Apod = *Apodytes dimidiata,* Ekbcap = *Ekebergia capensis)*

**Species diversity**

There were differences in species diversity index at the plot level (Table 2). Plot 16 was relatively with higher α-diversity followed by plot 15; while the least α-diversity was recorded from plot 30 and 31 (Table 2). Most of the study plots have evenness values ≥0.80, which shows the even distribution of species across the study plots. The highest woody species richness was recorded from plot 15 and 16, while the least was recorded from plots 30 and 31 (Table 2).

**Table 2.** Species richness (S), evenness (E) and diversity (H) in Beda-Buna coffee forest

| Plot Number | S | E | H |
|---|---|---|---|
| P1 | 10 | 0.858 | 1.975 |
| P2 | 10 | 0.88 | 2.026 |
| P3 | 14 | 0.968 | 2.554 |
| P4 | 14 | 0.927 | 2.446 |
| P5 | 14 | 0.732 | 1.931 |
| P6 | 14 | 0.727 | 1.919 |
| P7 | 14 | 0.733 | 1.935 |
| P8 | 6 | 0.793 | 1.422 |
| P9 | 6 | 0.816 | 1.461 |
| P10 | 8 | 0.819 | 1.704 |

| | | | |
|---|---|---|---|
| P11 | 8 | 0.818 | 1.701 |
| P12 | 10 | 0.915 | 2.106 |
| P13 | 10 | 0.897 | 2.065 |
| P14 | 10 | 0.899 | 2.07 |
| P15 | 21 | 0.894 | 2.721 |
| P16 | 22 | 0.915 | 2.827 |
| P17 | 11 | 0.89 | 2.134 |
| P18 | 11 | 0.872 | 2.09 |
| P19 | 10 | 0.821 | 1.891 |
| P20 | 10 | 0.776 | 1.786 |
| P21 | 9 | 0.711 | 1.562 |
| P22 | 9 | 0.72 | 1.582 |
| P23 | 11 | 0.918 | 2.201 |
| P24 | 11 | 0.926 | 2.221 |
| P25 | 11 | 0.962 | 2.307 |
| P26 | 11 | 0.962 | 2.307 |
| P27 | 11 | 0.962 | 2.307 |
| P28 | 7 | 0.935 | 1.818 |
| P29 | 7 | 0.973 | 1.894 |
| P30 | 3 | 0.921 | 1.011 |
| P31 | 3 | 0.946 | 1.04 |

**Importance Value Index (IVI)**

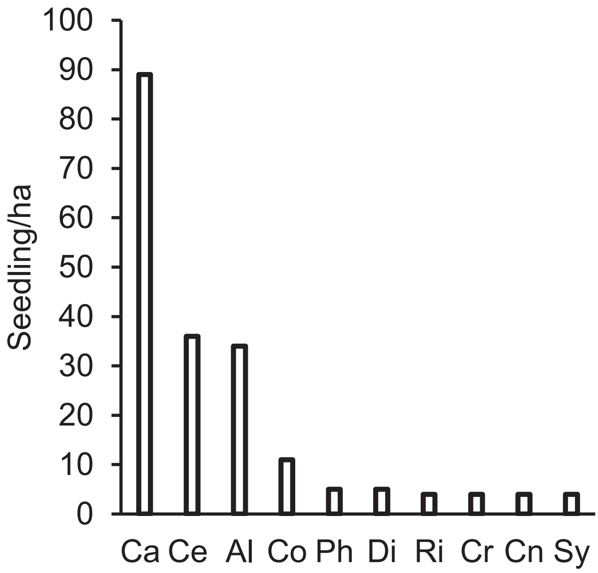
The upper canopy trees that provide shed for the coffee shrubs were also found ecologically very important. Except *Calpurnia aurea*, all plant species with more than 50 IVI values were the upper canopy trees. *Cordia africana, Diospyros abyssinica, Croton macrostachyus, Celtis africana* and *Albizia gummifera* were the most important species with the IVI values of 116.59, 110.89, 91.46, 82.47 and 66.083 respectively. These species belong to Ebenaceae, Boraginaceae, Fabaceae, Euphorbiaceae and Ulmaceae respectively. For the detail of the contribution of the remaining plant species see table 3.

**Table 3.** Importance value index for the trees and shrub species in Beda-Buna coffee forest

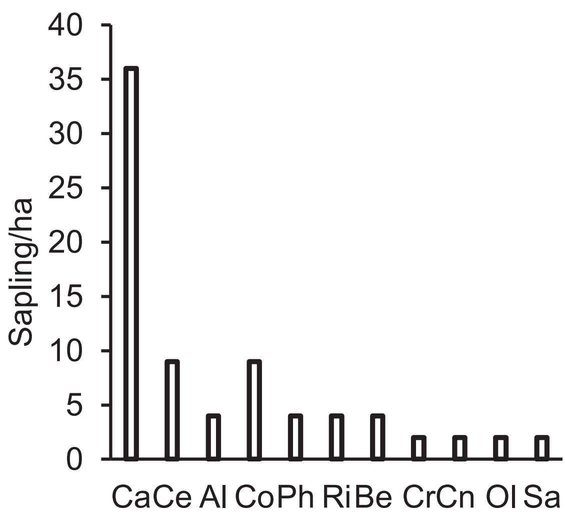
| Species Name | dj | nj | Xi (BA) | nj/N | dj/D | xj/x | IVI |
|---|---|---|---|---|---|---|---|
| *Croton macrostachyus* | 20 | 8 | 36.42 | 0.57 | 0.069 | 0.274 | **91.46** |
| *Calpurnia aurea* | 44 | 11 | 1.42 | 0.79 | 0.151 | 0.011 | **94.76** |
| *Canthium oligocarpum* | 4 | 2 | 0.002 | 0.14 | 0.014 | 0.00001 | 15.66 |
| *Cordia africana* | 27 | 11 | 38.15 | 0.79 | 0.093 | 0.287 | **116.59** |
| *Ekebergia capensis* | 1 | 1 | 0.203 | 0.07 | 0.003 | 0.002 | 7.64 |
| *Ritchiea albersii* | 4 | 4 | 0.0008 | 0.29 | 0.014 | 0.000006 | 2.99 |
| *Maytenus arbutifolia* | 2 | 1 | 0.027 | 0.07 | 0.007 | 0.0002 | 7.85 |
| *Ficus vasta* | 3 | 3 | 0.66 | 0.21 | 0.01 | 0.005 | 22.96 |
| *Diospyros abyssinica* | 19 | 10 | 43.7 | 0.71 | 0.065 | 0.329 | **110.89** |
| *Bersama abyssinica* | 3 | 3 | 0.0006 | 0.21 | 0.01 | 0.000004 | 22.46 |
| *Rothmannia urcelliformis* | 2 | 2 | 0.11 | 0.14 | 0.007 | 0.0009 | 15.06 |
| *Apodytes dimidiata* | 1 | 1 | 0.002 | 0.07 | 0.003 | 0.00001 | 7.49 |
| *Celtis africana* | 28 | 10 | 1.89 | 0.71 | 0.096 | 0.014 | **82.47** |
| *Olea welwitschii* | 4 | 2 | 1.67 | 0.14 | 0.014 | 0.013 | 16.92 |
| *Olea capensis* | 3 | 2 | 0.03 | 0.14 | 0.01 | 0.0002 | 15.34 |
| *Ehretia cymosa* | 4 | 2 | 0.03 | 0.14 | 0.014 | 0.0002 | 15.68 |
| *Sapium ellipticum* | 2 | 2 | 0.8 | 0.14 | 0.007 | 0.006 | 15.58 |
| *Syzygium guineense* | 8 | 6 | 2.55 | 0.43 | 0.027 | 0.0192 | 47.53 |
| *Phoenix reclinata* | 14 | 8 | 0.63 | 0.57 | 0.048 | 0.005 | **62.43** |
| *Albizia gummifera* | 26 | 8 | 1.36 | 0.57 | 0.089 | 0.00005 | **66.083** |
| *Schefflera abyssinica* | 1 | 1 | 1.36 | 0.07 | 0.003 | 0.01 | 8.514 |
| *Dracaena steudneri* | 2 | 2 | 2.36 | 0.14 | 0.007 | 0.018 | 16.753 |
| *Ficus sur* | 2 | 1 | 0.1 | 0.07 | 0.007 | 0.0008 | 7.908 |
| *Ficus thonningii* | 3 | 3 | 0.05 | 0.21 | 0.01 | 0.0004 | 22.496 |

**Regeneration status of Beda-Buna coffee forest**

There was poor regeneration of woody species in Beda-Buna coffee forest. Of the woody species found in this forest, we recorded seedlings only for 10 species (Figure 5A), saplings for 11 species (Figure 5B), while *Ekebergia capensis*, *Maytenus arbutifoloia*, *Ficus vasta*, *Bersama abyssinica*, *Apodytes dimidiata*, *Olea capensis*, *Ehretia cymosa*, *Albizia gummifera*, *Schefflera abyssinica*, *Dracaena steudneri*, *Ficus sur* and *Ficus thonningii* were not represented at both seedlings and sapling level. Relatively, the seedling density per hectare was more than the sapling density. Of the total woody species collections, seedlings and saplings were recorded for 13 species. *Calpurnia aurea* with *ca.* 89 seedlings and 36 saplings ha$^{-1}$, *Phoenix reclinata* with *ca.* 54 seedlings and 2 saplings, *Celtis africana* with *ca.*36 seedlings and 9 saplings, *Albizia sp.* With *ca.*34 seedlings and 4 saplings were the species with relatively more regeneration capacity in the forest. The dominant canopy trees such as *Cordia africana*, *Croton macrostachyus* and *Diospyros abyssinica* were represented by 11 and 9, 4 and 2, 5 and 0 seedlings and saplings, respectively. In general, *C. aurea* (125), *P. reclinata* (56), *Celtis africana* (45), *Albizia sp.* (38) and *Cordia africana* (20) seedlings + saplings ha$^{-1}$ have been recorded.




A

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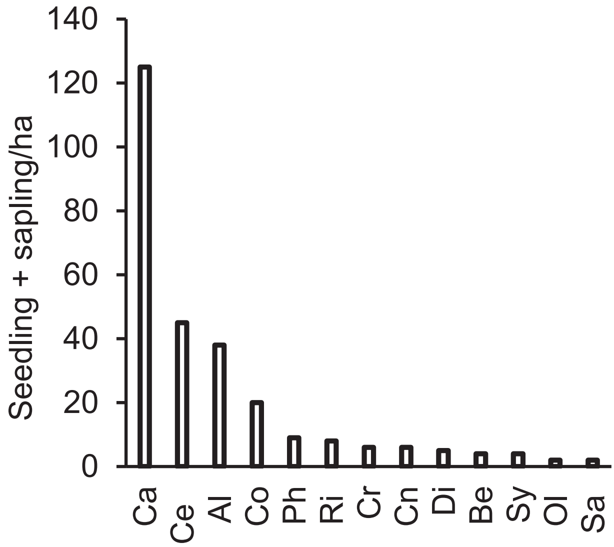


C

**Figure 5.** Regeneration status of some woody species in Beda-Buna coffee forest (Ca= *Calpurnia aurea*, Ph (*Phoenix reclinata*, Ce = *Celtis africana*, Al= *Albizia gummifera*, Co = *Cordia africana*, Di =*Diospyros abyssinica*, Ri = *Ritchiea albersii*, Cr = *Croton macrostachyus*, Cn = *Canthium oligocarpum*, Sy = *Syzygium guineense*, Be = *Bersama abyssinica*, Ol = *Olea welwitschi*, Sa = *Sapium ellipticum*)

## DISCUSSION

The species area curve of Beda-Buna forest showed that the sampling effort was exhaustive. In general, species area curve states that the number of species increases with the size of the area under consideration. The larger areas bear more number of species compared to the areas with small sizes. In this particular study, the number of species increased steadily for about the first 17 subplots and then smoothly increased up to about 29 subplots and then level off for the remaining two plots (Figure 3). Putting additional sample plots after the curve levels off is wastage of time and other resources.

Like any other traditionally managed coffee forests in Ethiopia, Beda-Buda coffee forest also contributed to the existence of forest patches and associated plant diversity. In agreement with other findings elsewhere in the world (Perfecto and Armbrecht, 2002; Rappole *et al.*, 2003; Dietsch *et al.*, 2004; Tejeda-Cruz and Sutherland, 2004; Raman, 2006) and in Ethiopia (Denu *et al.*, 2016), Beda-Buna semi-forest coffee has contributed to the conservation of plant diversity. It is the coffee that contributed to the persistence of patches of canopy trees in Beda-Buna coffee forest, in areas where the surrounding matrix is dominated by annual crops. This agrees with Perfecto and Armbrecht (2002); Denu *et al.* (2016). The variation of plant species in diversity, species richness and dominance in the study plots might be attributed to the differences in the coffee forest management which varies from person to person. For example, Plot 15 and 16 relatively have higher species diversity compared to Plot 30 and 31 which probably be due to variation in management intensities. Beda-Buna coffee forest is home for canopy trees such as *Cordia africana*, *Diospyros abyssinica*, *Croton macrostachyus*, *Celtis africana* and *Albizia gummifera* which are ecologically the most important canopy trees (Denu *et al.,* 2016). Regardless of the intensive ground clearing before harvesting the coffee berries, still there are some climax species for shed provision. These species could escape local extinction under the provision of appropriate management strategies. Similar results were reported in Garuke (Aerts *et al.,* 2011) and in Setem (Denu *et al.* (2016) districts, both located in northwest of Jimma Town, where both studies showed the existence of climax species as a result of traditional coffee management system. Of the tree species in Beda-Buna coffee forest, *Cordia africana* is relatively with the highest population density. The tree is the source of high quality timber for making household furniture in southwest Ethiopia and it is found in good number in private coffee plots and agricultural lands than in the wild (Denu *et al.*, 2016; Raga and Denu, 2017).

Of all the plant growth forms, lianas were the most affected woody plants in the conversion of natural forest to semi-forest coffee system. Lianas' impact on the growth morphology of coffee and its yield is critical. It also blocks ease movement during the harvest of ripened coffee berries (personal observation). It is this feature of the lianas that put them at risk in almost all coffee management systems. Like in any coffee forests, the woody as well as herbaceous climbers in Beda-Buna coffee forest are at risk due to their impact on the coffee yield.

The poor regeneration of plant species in this coffee forest was attributed to the intensity of coffee management. The intense clearing of the under canopy species before harvesting coffee berries has contributed to the poor regeneration of canopy trees in this coffee forest. This agrees with Hundera *et al.* (2013). The ground cover is turned up and down several times by local people for collecting the dropped coffee berries during and/or before harvesting. This could have contributed to the poor regeneration capacity of canopy trees in Beda-Buna coffee forest.

## CONCLUSION

Semi-forest coffee has contributed to the persistence of small forest patches and associated plant diversity. Coffee growing under the shade of natural and indigenous forest trees has both positive and negative impacts on the plant species diversity. Semi-forest coffee system has contributed to the conservation of Beda-Buna forest patch with about 80 species of vascular plants. These plant species would not be there if the coffee farm had been changed to other land use systems such as farming that involves annual crops.

Coffee growing has also a negative impact on the plant diversity. There is frequent clearing of the ground under the coffee tree which is not, of course selective. Even the seedlings and saplings of the well represented canopy trees of this coffee forest such as *Cordia africana*, *Croton macrostachyus* and *Diospyros abyssinica* were hardly seen during this study. The lianas were also at risk due to their impact on the coffee shrub and yield. Maintaining some strips of land between consecutive coffee plots would help the conservation of lianas and other tree species which would otherwise at risk of local extinction.

The high basal area value attributed mostly by few canopy tree species in this forest indicates that the existing trees are mature and aged. If these trees die out there is no enough seedling and sapling density to replace them. Therefore, I recommend the need to have appropriate management strategies that could help the recruitment of seedlings and saplings into the adult trees. This is vital for sustainability of the coffee farm and the yield obtained from it.

## ACKNOWLEDGEMENTS

Ethiopian Red Cross Society, Jimma Branch is highly acknowledged for its due permission to collect data from the forest.

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