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Floristic Composition and Vegetation Structure of Woody Species in Lammo Natural Forest in Tembaro Woreda, Kambata-Tambaro Zone, Southern Ethiopia

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Abstract: This study was conducted to investigate the floristic composition of woody species in Lammo natural Forest, Tembaro woreda, Kembata-Tembaro zone, Southern Ethiopia. 52 quadrants, each with 20 m x 20 m (400 m^2) were systematically laid to collect vegetation data along line transects at the distance of 60m from each other. Vegetation structures such as DBH, basal area, height, frequency, IVI and Species population structure were computed. Specimens were collected, pressed, dried and taken to Ethiopian National Herbarium for identification. Data analysis was carried out using Shannon-Wiener Diversity index, Microsoft Excel, R-package, past and Sorensen's similarity index. 54 woody species belonging to 46 genera from 29 families were identified. The dominant family was Myrtaceae followed by Euphorbiaceae. The vegetation cluster classification resulted in three plant communities. Most of the species in the study area fall under middle diameter and height classes. The results of population structure for the forest, revealed the signs of some disturbances and hence some management and conservation practices need to be in place.

Keywords: Basal Area, Community Classification, DBH, Floristic Composition

1. Introduction

Tropical forests constitute the most diverse plant communities on earth [1]. Ethiopia is one of the tropical countries with diverse flora and fauna. However, the forest cover in Ethiopia has been declining rapidly due to anthropogenic impacts [2]. A reduction of biological diversity will negatively affect vital ecosystem functions that regulate the Earth system upon which humans ultimately depend [3]. An obvious approach to conserve plant biodiversity is to map distributional patterns and look for concentrations of diversity and endemism [4]. Further, management of forest requires understanding of its composition in relation to other forests, the effects of past impacts on the present status and the present relationship of the forest with surrounding land uses [5].

Most of the remaining forests of Ethiopia are confined to the south and southwest parts of the country, which are less accessible, and/or less populated [6]. Nowadays, even the remnant natural forests in these areas are continuously threatened by human activities. Lammo Natural Forest is also one of the remaining forests in south region and so far, no studies have been reported on the forest. Therefore, this study was undertaken to describe and provide valuable information on floristic composition and vegetation structure of woody species in the forest.

2. Materials and Methods

2.1. Description of the Study Area

The study area is located within the geographic co-ordinates of 7º 17' 030"N to 7º 19' 55N latitudes and 37º 33' 13"E to 37º 55' 40"E longitudes. It is situated at a distance of about 400kms South of Addis Ababa, between the altitudinal ranges of 2010 and 2484-m.as.l. The natural vegetation of the area is a broad–leaved and evergreen with the most dominant

tree species including *Syzygium guineense, Croton macrostachyus*, *Ficus sycomorus,* and *Ekebergia capensis.*

2.2. Data Collection and Identification

The woody species specimens were collected by laying a quadrates of 20×20 m (400m^2) at a distance of 60m along the transects. 52 plots of the forest were sampled and the specimens of these plots were counted, numbered and pressed; height and Diameter at Breast Height (DBH) of each species with height greater than or equal to 2.5 m and DBH greater than or equal to 3 cm in each plot were measured. The collections were first named using the folk taxonomy as field identification and formal taxonomic identification to species level was made later using the voucher specimens at the National Herbarium, Addis Ababa University.

3. Methods of Data Analysis

3.1. Vegetation Classification

Cluster analysis was used for the purpose of vegetation classification into different community types using the statistical software R-package for windows version 2.15.0 [7]. The Indicator Species Analysis was made to compare the species present in each community.

3.2. Diversity Index

Species diversity and evenness are often calculated using Shannon-Wiener diversity index [8].

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Where: H′= Shannon Diversity Index

s = the number of species

Pi = the proportion of individuals or the abundance of the ith species expressed as a proportion of total cover and

ln = natural logarithm.

And that of Sorensen`s similarity was calculated by using the formula Ss = 2 a /2a+b+c

Where: Ss = Sorenson`s similarity coefficient

a = Number of species common to both communities

b = number of species in community1

c = number of species in community 2

3.3. Vegetation Structure

To describe the vegetation structure of the forest, density, frequency, height, Diameter at Breast Height (DBH), composition, family importance value (FIV), species importance value (SIV) and basal area were calculated following [9].

BA = $\pi d^2/4$, where BA=Basal Area in m^2 per hectare

d = diameter at breast height (m)

π = 3.14

3.4. Species Population Structure

Woody species in the forest with a diameter at breast height (DBH) greater than 3 cm, and height greater than 2.5 m were measured to analyze the DBH class distribution by classifying the DBH values of the species in to seven class intervals (3-20cm, 21-40cm, 41-60cm, 61-80cm, 81-100cm, 101-120cm and >120cm. Individuals with DBH less than 3 cm, and height less than 2.5 m were counted. Similarly, their height was measured and classified into eight class intervals. Thus, height classes were ranked as <5m, 5.1-10m, 10.1-15m, 15.1-20m, 20.1-25m, 25.1-30m, 30.1-35m and >35m.

4. Results and Discussion

4.1. Floristic Composition

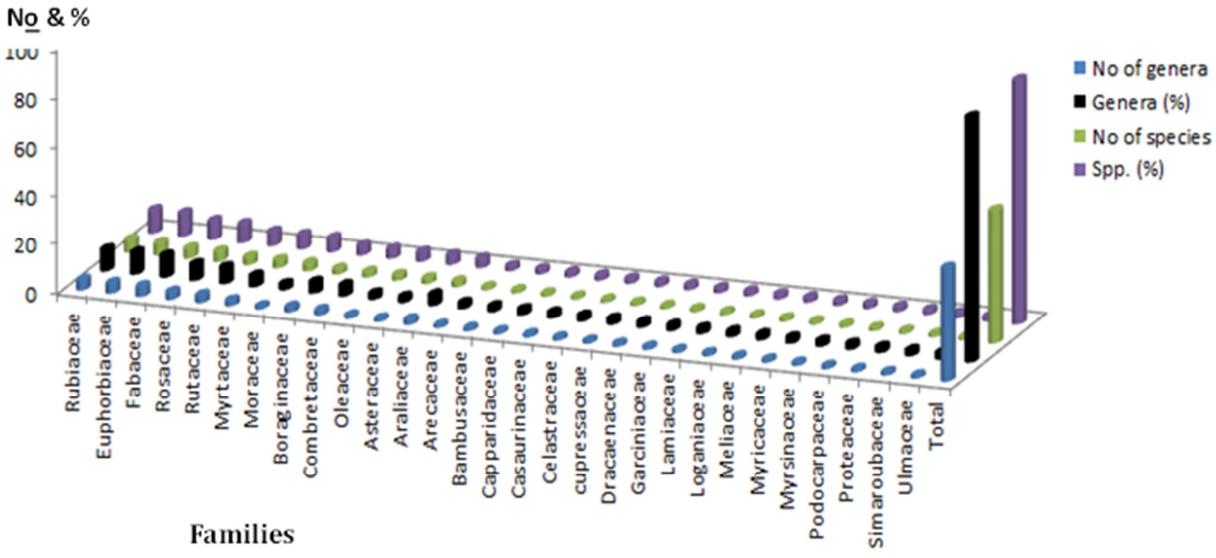

Fig. 1. *Showing families with their representative genera, species and their percentage.*

In the study, 54 woody species, belonging to 46 genera and 29 plant families were recorded. Rubiacea, Euphorbiaceae and Fabaceae each represented by 8.7% of the genera followed by Rutaceae and Rosaceae each representing 6.5% of the genera and 4.35% of the genera was represented by each of the other four families (Myrtaceae, Boraginaceae, Combrtaceae and Araliaceae). The remaining 20 families were represented by only a single genus. With respect to species composition, Rubiacea and Euphorbiaceae were found to be represented by five species each (9.26%) followed by Fabaceae and Rosaceae each having four species (7.4%). Rutaceae, Myrtaceae and Moraceae each represented by three species; Boraginaceae, Combretaceae, Oleaceae, Asteraceae and Araliaceae each represented by two species and the remaining 17 families were found to be represented by only a single species and it is shown in figure 1.

4.2. Vegetation Classification

From cluster analysis of the forest, three plant communities were identified as shown in figure 2. Each community was named by the species having higher indicator value. Accordingly, the three identified communities were described as Myrica salicifolia- Maytenus ovata (Community type1), Millettia ferrugina-Syzgium guineense (Communitytype 2), and Macaranga capensis- Galiniera saxifraga (Community type 3).

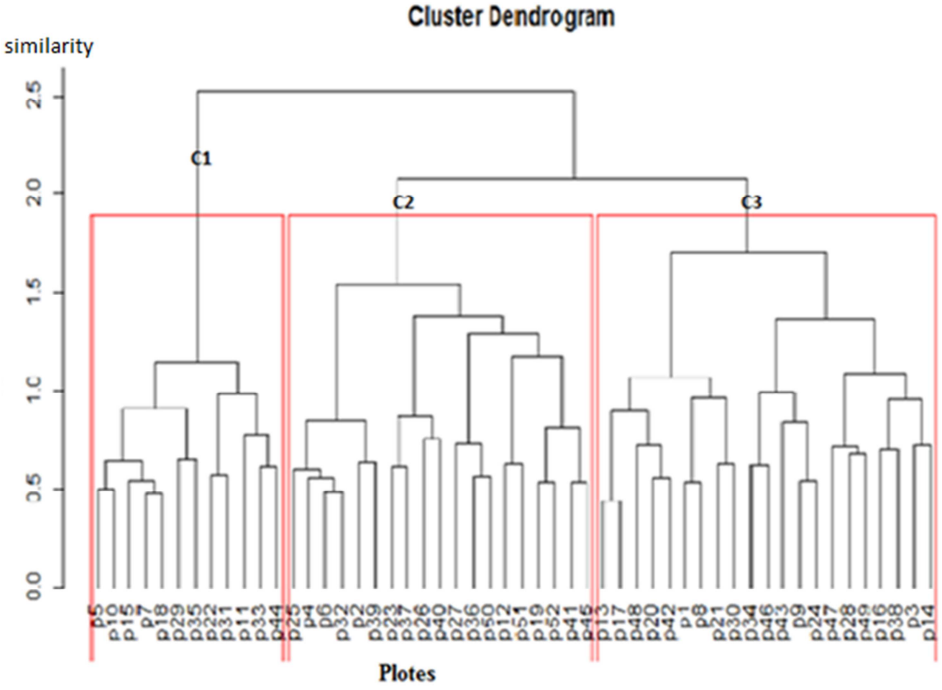

Fig. 2. *Dendrogram showing the three community types obtained from cluster analysis of the Forest.*

4.2.1. Myrica salicifolia- Maytenus Ovata Community Type

This community comprised of 12 quadrates (about 0.48 hectar) and two species were found to be indicator species (Myrica salicifolia and Maytenus ovata) with significant indicator values in the community (Annex1)

4.2.2. Millettia Ferrugina- Syzygium Guineense Community Type

This community type was represented by 19 quadrates (0.76ha) and two species (*Millettia ferrugina* and *Syzygium guineense* were found to be indicator species of the community as they displayed the highest indicator values.

4.2.3. Macaranga Capensis- Galiniera Saxifraga Community Type

The two indicator species of this community were *Macaranga capensis and Galiniera saxifraga* and it comprised of 21 quadrates (0.84ha).

4.3. Species Diversity, Evenness and Richness in the Communities

Shannon Wiener diversity index revealed that *Macaranga capensis- Galiniera saxifraga* community type had the highest species diversity and richness compared to the other two community types. The possible reason for high diversity and richness could be its being situated at the medium average altitude interval (2230 m.a.s.l) which is relatively more favorable for growth and reproduction of a variety of species in the area. In contrast, *Myrica salicifolia- Maytenus ovata* community type had the least species diversity and richness. This could be associated to growth at a relatively higher altitude in which only more adaptive species potentially grow better than the others. The third community type, which had lowest average altitude range of the study site, was characterized by the intermediate species diversity and richness (Table 1).

Table 1. *Shanon-Wiener Diversity Index of the three communities in Lammo natural forest.*

Communities	Average altitude (ma.s.l)	Species Richness	Diversity Index (H')	H'max	Evenness (H'/H'max)
1	2280	43	3.751	3.964278	0.9462
2	2190	45	3.774	3.970542	0.9505
3	2230	49	3.789	3.93213	0.9636

4.4. Similarity of Species Composition Among the Three Community Types

The result of Sorensen's similarity coefficient of the three communities displayed, community 1 and 3 share more species in common (90.3%) followed by 2 and 3 (87.9%) and that of community 1 and 2 was relatively low (82%).

Table 2. *The similarity index of plant species composition in three communities.*

Community types	1	2	3
1	-	0.82	0.903
2	-	-	0.879
3	-	-	-

4.5. Density

Of all the collected and identified families of woody species in the forest, Myrtaceae family was found to have highest number of tree individuals per hectare (12.9%) followed by Euphorbiaceae (12. 87%). On the other hand, Garciniaceae (0.37%) was found to have the least number of individuals per hectare.

4.6. Dominant Species of the Forest

The species having relatively higher species importance value (SIV) and basal area (*BA)* were considered as dominant species. Accordingly, *Croton macrostachyus with SIV (31), Syzygium guineense (18.97), Ficus sycomorus (17.6), Eucalpytus globulus (12.3), Galiniera coffeoides (12.2), Millettia ferrugina (9.8), Schefflera abyssinica (9.6), Ekebergia capensis (9.2), Myrica salicifolia (7.2), Eucalyptus camaldulensis (*6.7*)* were some of the dominating species of the forest. The dominance of these species was because of their abundance in distribution and high basal area within the forest.

4.7. Commercially Important Tree Species in the Forest

The forest contains some of the major commercially important indigenous tree species reported by Ethiopian Forestry Action Plan [10]. These tree species include *Albizia gummifera, Celtis africana, Croton macrostachyus, Ekebergia capensis, Hagenia abyssinica, Olea welwitschii, Prunus africana* and *Syzygium guineense*. In addition, some endemic tree species of Ethiopia, such as *Millettia ferruginea*, *Vepris dainellii* and *Erythrina brucei* were found in the forest.

4.8. Vegetation Structure of the Forest

4.8.1. Diameter at Breast Height (DBH)

In contrast to the similar study conducted in Sese forest that showed the inverted J-shape pattern of distribution [11], the distribution of individual woody species across the DBH classes displayed irregular shaped pattern of distribution. The middle DBH classes were found to have relatively higher number of individuals than that of the lower and the top classes. About 70% of the individuals were found in the middle four classes (21-40cm, 41-60cm, 61-80cm and 81-100cm). Less percentage of individuals was recorded for both the lowest and the highest DBH classes. This indicates that small sized and very large sized individuals were not common in Lammo natural forest. Hence, this distribution depicts that the forest is on the status of low regeneration and there seems to be selective removal of bigger individuals for different purposes.

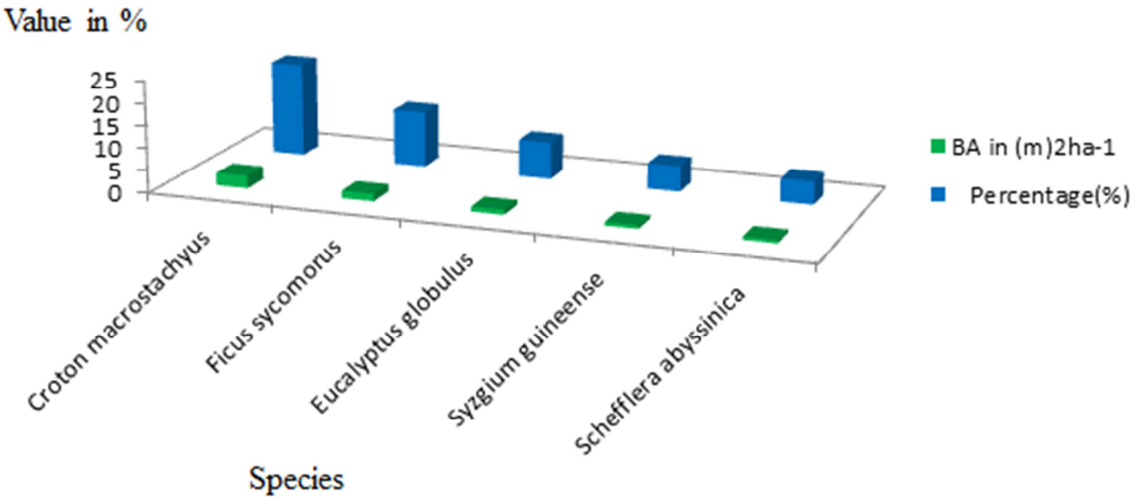

Fig. 3. *BA of the five most important tree species in the forest.*

4.8.2. Basal Area of the Species in the Forest

The total basal area (BA) of the recorded species in the forest was found to be 13.35m^2/ha. *Croton macrostachyus, Ficus sycomorus, Eucalyptus globules, Syzgium guineense* and *Schefflera abyssinica* covered about 52% of the total basal area. According to the standard set by Dawkins, (1959) cited in [12], the normal value of basal area (BA) for virgin tropical rain forest in Africa is expected to be between 23 and 37-m2 ha^{-1}. In this regard, Lammo natural forest displayed lower basal area that might indicate the presence of different factors that could potentially affect the composition in the area. These factors include –the destruction of mature trees for logging, timber production and fuel wood collection. Compared to similar studies in Ethiopia, the BA of Lammo natural forest is relatively greater than that of Beschillo and Abay Riverine Vegetation [12] with total BA (12.6) and far less than that of Komto Afromontane Rainforest [13] with total BA (50.72m^2/ha).

4.8.3. Height Class

Most of the individuals in the forest belong to the third height class (10.1-15m) followed by the second height class (5.1-10m). The least number of individuals corresponds to the biggest height class (>35m). This indicates that most of the recorded species of the forest (about 60%) were short (<15m in height). Few in number or the absence of large individuals in the forest might be associated with the selective cutting of species for various purposes.

4.8.4. Family Importance Value (FIV)

Six of the families (Euphorbiaceous, Myrtaceae, Moraceae, Rubiaceae, Fabaceae and Rutaceae) together contributed about 50% of the total FIV. Euphorbiaceae displayed the highest FIV and is represented by five species. Families Myrtaceae, Moraceae, Rubiaceae, Fabaceae and Rutaceae were respectively ranked to be with the second, third, fourth, fifth and sixth highest FIVs. Loganiaceae family, which was represented by a single species, displayed the least FIV.

4.8.5. Species Importance Value (SIV)

About 35% of the total SIV was contributed by the six most dominant species in the forest. Accordingly, these species include Croton macrostachyus, Syzgium guineense ssp.afromontanum, Ficus sycomorus, Eucalyptus globules, Galiniera coffeoides and Millettia ferrugina. In contrast to this, most of the species displayed very low SIV. The possible reason for this could be either the selective cutting of these species by the local people or unfavorable conditions. It indicates that the requirement of conservation and management of the forest as a whole.

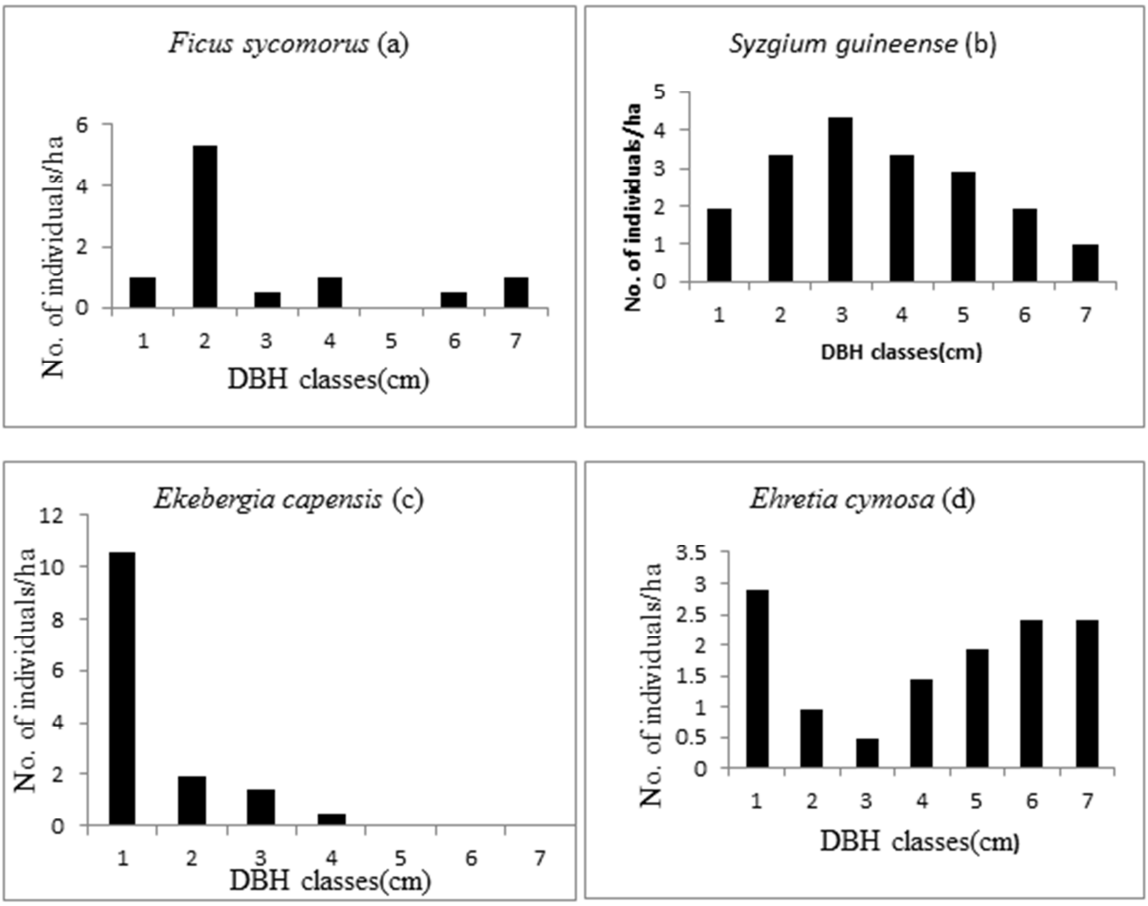

Fig. 4. *Four patterns of Species population structure in Lammo natural forest.*

4.8.6. Species Population Structure

Four different patterns of distribution were recognized in the forest. The first pattern is described as irregular where no defined pattern will be observed when one goes across the DBH classes. Most of the species in the forest displayed such pattern of population structure. This type of pattern could be the result of selective cutting of individual species by the local people. *Ficus sycomorus* was found to be the ideal representative example for this pattern of distribution.

The second pattern showed a bell-shaped distribution pattern. The number of individuals increases with increasing DBH up to certain point then decreases with increase in DBH. This pattern of distribution suggests that the lower regeneration and recruitment capacity of these species and indicates the management and conservation problems (Example, Syzgium *guineense).*

The third pattern of population structure exhibited the inverted J-shaped distribution. This pattern of distribution suggests a good reproduction and recruitment capacity of the species. It shows that a higher number of individuals in the lower DBH classes and decreases with increasing in DBH. *Ekebergia capensis* was among the representative examples of this pattern of distribution.

The fourth pattern was found to be a U-shaped pattern of distribution. This pattern is characterized by having large number of individuals in the lower DBH class and lower or the total absence in the next two middle classes and gradually increasing to the higher DBH class. *Ehretia cymosa* was in this category of distribution patterns.

5. Conclusion

In the study from 52 quadrates (2.08ha), 54 plant species belonging to 46 genera and 29 families were identified. Myrtaceae was found to be the most abundant and dominant family followed by Euphorbiaceae. The vegetation was classified into three plant community types. The variation in species composition and diversity among these communities could be because of different environmental factors (anthropogenic and natural). The forest contains some of commercially important and endemic plant species of Ethiopia. For structural analysis, DBH and height records were classified in to class intervals and more number of individuals was recorded for the intermediate classes. The number of matured individuals (top class) as well as seedlings and saplings were found to be low and in some species, no single seedling and/or sapling were recorded. The general distribution pattern of species population structure in the forest based on the DBH value revealed four structural patterns. This population dynamics within the forest revealed the signs of some disturbances and requires for management and conservation practices as soon as possible.

Annex 1

Annex 1. *The indicator species and their P*.value in three communities of Lammo natural forest.*

species	Com.1	Com.2	Com.3	P*.value
Acacia tortilis	0.000000000	0.097435897	0.080971660	0.602
Afrocurps falcatus	0.077896787	0.049367089	0.000000000	0.426
Albizia gummfera	0.019180295	0.048622047	0.067343556	0.848
Brucea antidysenterica	0.017603595	0.022312556	0.115374253	0.411
Buddleja polystachya	0.000000000	0.111038961	0.013670540	0.233
Canthium lactescens	0.022890187	0.009671104	0.080369287	0.63
Canthium oligocerpum	0.115841886	0.065257596	0.018076896	0.507
Casurina equstifolia	0.000000000	0.016101695	0.071364853	0.391
Celtis africana	0.011173841	0.151070336	0.005230967	0.049
Clausena anisata	0.011009706	0.093032015	0.061849539	0.703
Coffea arabica	0.033444816	0.056521739	0.000000000	0.775
Combretum molle	0.137953290	0.006476141	0.014351558	0.224
Cordia africana	0.000000000	0.117525773	0.065111232	0.342
Croton macrostachyus	0.075276406	0.107339450	0.125543216	0.902
Dracaena steudneri	0.000000000	0.170149254	0.007855460	0.076
Ehretia cymosa	0.038036134	0.008035133	0.155805910	0.228
Ekebergia capensis	0.120263736	0.070571429	0.086015038	0.872
Erythrina brucei	0.032954644	0.013923337	0.015427520	1
Eucalyptus camaldulensis	0.000000000	0.173780488	0.032092426	0.127
Eucalyptus globulus	0.098623026	0.034723524	0.071819662	0.78
Euphorbia ampliphylla	0.199731939	0.004219337	0.042076493	0.108
Euphorbia candelabrum	0.120677488	0.000000000	0.050217286	0.214
Ficus sur	0.106487320	0.007498482	0.008308567	0.347
Ficus sycomorus	0.053644282	0.063461186	0.070317103	1
Ficus vasta	0.028742153	0.012143559	0.040366403	0.918
Galiniera saxifraga	0.010798215	0.004562246	**0.242645772**	0.03
Galiniera coffeoides	0.116183726	0.044625113	0.147102173	0.666
Garcinia buchanani	0.091968860	0.006476141	0.028703116	0.462
Gardenia ternifolia	0.020968988	0.035437590	0.039266027	1
Grevillea robusta	0.037717122	0.132795699	0.035314092	0.463

species	Com.1	Com.2	Com.3	P*.value
Hagenia abyssinica	0.017812778	0.045155393	0.033355784	0.964
Juniprus procera	0.004347229	0.110202261	0.185196781	0.293
Macaranga capensis	0.012651274	0.016035490	**0.248749986**	0.048
Maytenus ovatus	**0.213818489**	0.033876867	0.004170744	0.049
Millettia ferrugina	0.016641485	**0.221477370**	0.068167858	0.046
Myrica salicifolia	**0.270883287**	0.041617523	0.004611360	0.019
Olea europea	0.110166216	0.062060302	0.005730406	0.454
Olea welwitschii	0.100334448	0.141304348	0.000000000	0.253
Oxytenanthera abyssinica	0.081422756	0.022934076	0.025411719	0.582
Phoenix abyssinica	0.106681640	0.045072993	0.037456781	0.614
Pilostigma thonningii	0.121401441	0.005699123	0.037888908	0.352
Polyscias fuluva	0.000000000	0.073076923	0.053981107	0.654
Premna schimperi	0.077035702	0.054245974	0.064113431	0.978
Prunus africana	0.011118589	0.164416128	0.020820404	0.196
Ricinus commnus	0.076570450	0.008087754	0.035846000	0.833
Ritichea albersii	0.066151670	0.069872702	0.023226383	0.903
Rubus apetalus	0.066395842	0.042078365	0.007770704	0.718
Schefflera abyssinica	0.061831347	0.078371232	0.032564224	0.892
Syzygium guineense	0.122509511	**0.215004191**	0.079410597	0.048
Teclea nobilis	0.098503013	0.020808762	0.076855998	0.747
Terminalia brownii	0.000000000	0.027536232	0.152555301	0.177
Vepris dainellii	0.106261506	0.022447743	0.049745691	0.608
Vernonia amygdalina	0.184946341	0.023441949	0.017316306	0.114
Vernonia auriculifera	0.000000000	0.027536232	0.152555301	0.156

Com.1, 2, 3= community 1, 2, 3; and the bolded are the value of species with higher IVI

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