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Full Length Research Paper

Floristic composition of herbaceous flowering plant species in Lalay and Tahtay Michew Districts, Central Zone of Tigray, Ethiopia

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This study was carried out in Lalay and Tahtay Maichew districts, Central Zone of Tigray, Ethiopia. The main objectives of the study were to: identify herbaceous flowering plant species found in the study area and to identify community types of the vegetation of the study area. Within 65 sample quadrats, different herbaceous species were collected for taxonomic identification using preferential sampling method and coded for an analysis from 1m x 1m sub-quadrats placed within 20m x 20m quadrat. A total of 132 herbaceous flowering plant species of vascular plants belonging to 99 genera and 34 families were identified. With regards to species number, the most dominant plant family is Poaceae (34 species), followed by Asteraceae (16 species), Fabaceae (14 species). Four community types were also identified at 47.94% to 31.42% similarity levels.

Key words: Floristic composition, taxonomic identification, community types, herbaceous plant species, Lalay and Tahtay Maichew districts.

INTRODUCTION

Ecosystems are geographic regions that contain biological communities related with the abiotic circumstances such as temperature, rainfall and seasons. The biodiversity of the different ecosystems of the globe is not evenly distributed and some regions of the world like those of tropics are relatively richer in biodiversity as compared to temperate areas. As stated by WCMC (1992) Ethiopia is one of the top 25 richest countries of the world in terms of biodiversity. The decrease of biodiversity in agricultural landscapes due to increasing demand for agricultural land is increasing concern. Consequently, conservation of plant species within patches of degraded areas has been considered to be a step towards reversing this trend Mponela (2010). Botanical assessments such as floristic composition and structure studies are essential in understanding the plant biodiversity. Knowledge of the floristic composition of protected areas is also useful in identifying important

elements of plant diversity like protecting threatened species through monitoring protected areas and others. Information on floral composition and diversity are absolutely essential in understanding forests ecosystem dynamics and conservation.

Nowadays, as the use of land for intensification of agriculture production increases, the demand for plants for different purposes is also increasing, affecting the vegetation in the area. Lalay and Tahtay Maichew districts are two districts where there is intensive use of land for agriculture with a high demand of plants for different purposes that are affecting the vegetation. Various plant species provide many uses such as habitat for wildlife, source of foods and drinks, raw materials for different skills and crafts, spiritual applications, herbal medicines, etc. Therefore, detailed biodiversity and ecological studies are desirable to draw the attention of stakeholders to understand the ecosystem services of this biodiversity assemblage and undertake appropriate conservation measures. Due to absence of any previous biodiversity study in the area, this study is undertaken to provide information on floristic composition in the study area.

MATERIAL AND METHODS

Description of the Study Area

Geographical location

Lalay and Tahtay Maichew districts are located in central Zone of Tigray National Regional State; Lalay Maichew district includes the known historical town, Axum and Tahtay Maichew district includes a town called Wukro-Maray. Lalay Maichew district has a total area of 41,882 km^2; and an altitudinal range of 1982-2301 m a.s.l. It also lies approximately between 13^0 58' and $14^0$16' North and $038^0$37' and $038^0$55'East (Figure 1). Tahtay Maichew district covers a total area of 18,618 km^2 and with an altitudinal range of 1992-2333 m a.s.l. and lies approximately between 13^0 52' and14^0 19' North and 38^0 29' and 38^0 42' East.

Climate

Climate diagram was computed by using R for windows version 2.11.1 statistical package. Meteorological data obtained from National Meteorology Service Agency (ten years (2001-2010) data) indicates that the mean annual rainfall in Lalay Maichew is about 613 mm and it obtains high rainfall between June to end of August and low rainfall towards September (Figure 2). The highest mean annual rainfall of the study area was 179.47 mm recorded in August followed by 118.42 in July whereas the lowest mean annual rainfall was 2.344 mm recorded in February. The mean annual temperature is about 19.9^0C and the mean minimum temperature was 9.9ºC recorded in December, whereas the highest was 30.3ºC recorded in April and May.

Human and Livestock population

The total population of the two districts (Lalay and Tahtay Maichew) is estimated to be 84,529 and 116,842 respectively. Crop production and livestock rearing are the main activities of the people of the districts. Due to rainfall during the rainy season, there is soil erosion on the degraded land, which leads to loss of soil fertility. Livestock population of Lalay Maichew is about 191,952 consisting of 40,142 cattle; 50,303 goats; 31 mules; 73 horses; 7,667 donkeys; 35,532 sheep and 58, 204 poultry. The livestock population in Tahtay Maichew is about 247,907 consisting of 75,707 cattle; 55,517 goats; 110 mules; 6,716 donkeys; 25,195 sheep and 84,102 poultry. Problems associated with shortage of browsing lands and inadequate health services and facilities are common.

Materials

The materials used during the plant data collection in the field were:

1. Herbarium presses – woody frame, straps, blotters, ventilators and flimsies
2. Field materials – GPS ,sampling frame of 1 m^2, digger, scissors, plastic bags, digital camera, lens for looking at details fine parts of the herbaceous plants, note book, pencil and tag labels

Methods

Reconnaissance survey

Reconnaissance survey of the vegetation of the two districts was conducted from August 22 to September 2 to get an overview of the study areas. The survey identifies the sites for detailed floristic sampling and collection of the herbaceous species. During the survey, 10 representative sites in 10 “kebeles” distributed at diffe-

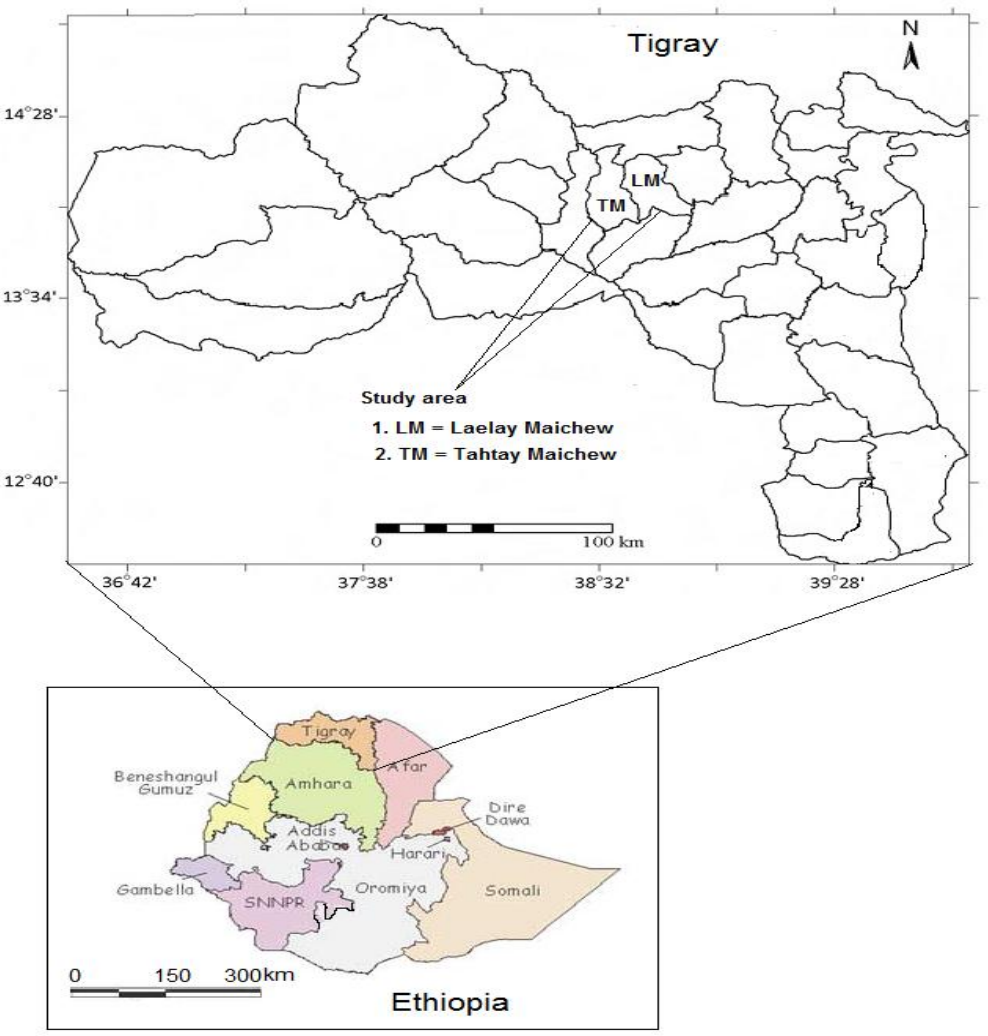

Figure 1. Map of Ethiopia and the study area.

rent altitudes were selected from the 32 “kebeles” for floristic composition of herbaceous flowering plants.

Sampling Design and data gathering techniques

Vegetation data were collected from sample quadrants using preferential sampling method. By sampling the quadrants from churches, borders and bunds, rehabilitated gullies, areas protected from grazing and areas where free range grazing takes place. Within 65 sample quadrants of the different herbaceous species was collected for taxonomic identification and coded for analysis of relative abundance in 1m x 1m quadrants placed within 20m x 20m quadrant (Figure 3) in the sites being studied. A total of five 1 x 1 sub-quadrants were taken from each quadrant of the major herbaceous vegetation types as shown in Figure 3. A complete list of herbaceous plants was done for each quadrant and percent cover value was estimated for each species and later converted to the Braun-Blanquet 1-9 scale as modified by Van der Maarel (1979). During data gathering the physiographic variables such as altitude, latitude, and elevation using GPS were recorded. Plant specimens encountered in each of the quadrants were collected and brought to the National Herbarium (ETH) of Addis Ababa University for identification, using published

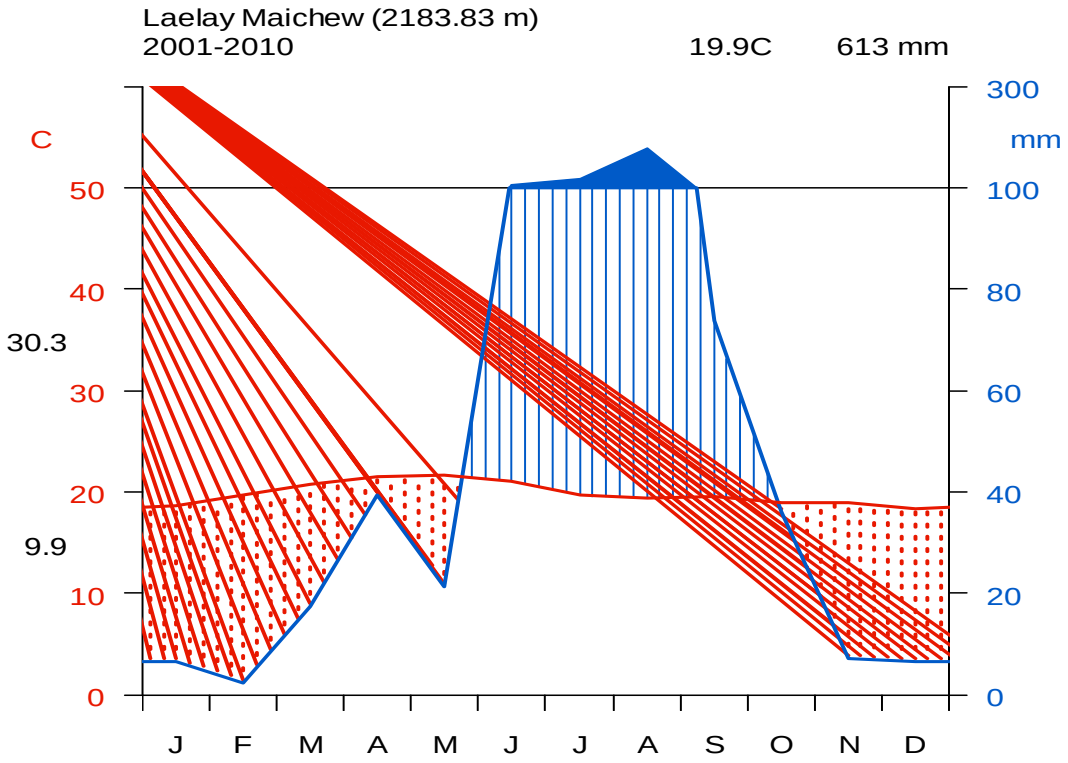

Figure 2. Climadiagram showing rainfall distribution and temperature variation from 2001-2010 of Lalay Maichew at Axum Station.
Source: Data obtained from National Meteorological Service Agency (2011).

volumes of the Flora of Ethiopia and Eritrea and comparing specimens with authenticated once deposited at the National Herbarium (ETH).

Data Analysis

Plant community type identification

The plant community classification was made using cover abundance values as class labels. In addition, a floristic approach of Braun-Blanquet (1983) scale used to determine the relative cover proportion of individual species. All herbaceous plant species present in sampling unit were recorded and percentage canopy cover of each species was estimated visually converted in to 1-9 Braun-Blanquet scale later modified by Van der Maarel (1979)

1 = rare generally only one individual;
2 = sporadic (few) which are less than 5% cover of the total area;
3 = abundant with less than 5% cover of the total area;
4 = very abundant and less than 5% cover of the total area;
5 = 5-12% cover of the total area;
6 = 12.5-25% cover of the total area;
7 = 25- 50% cover of the total area;
8 = 50-75% cover of the total area;
9 = 75-100% cover of the total area

Finally, the data were entered into the spreadsheet of R.2.11.1 Program.

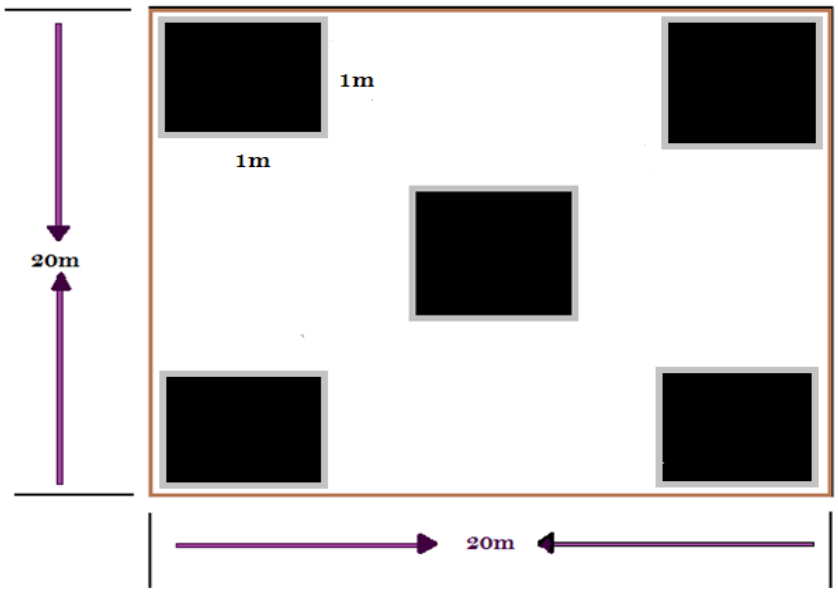

Figure 3. Sampling design of herbaceous flowering plant species in study area.

Diversity and similarity indices

Shannon and Wiener (1949) index of species diversity was applied to quantify species diversity and richness. This method is one of the most widely used approaches in measuring the diversity of species. The two main techniques of measuring diversity are richness and evenness. Richness is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites. Species richness index has a great importance in assessing taxonomic, structural and ecological value of a given habitat. Evenness is a measure of abundance of the different species that make up the richness of the area. Species diversity shows the product of species richness and evenness.

Shannon-Wiener Shannon and Wiener (1949) diversity index is calculated as follows

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where, H' = Shannon diversity index

S = the number of species

Pi = the abundance i^{th} species expressed as proportion of total cover

ln = log $base_n$

Evenness (Equitability)

Evenness (J) measures degree of association between communities. Equitability (Evenness) index is calculated using the formula:

Equitability:

$$J = \frac{H'}{H'Max}$$

H'= Shannon diversity index, H' max=lnS.

$$J = \frac{-\sum_{i=1}^{S} p_i \ln p_i}{\ln S}$$

Where,

J = Equitability

H' = Shannon diversity index

S = the number of species

Pi = the abundance i^{th} species expressed as proportion of total cover

ln = log $base_n$

The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is distributed within the given area.

RESULTS AND DISCUSSIONS

A total of 132 species of herbaceous flowering plants belonging to 99 genera and 34 families were identified from 65 quadrats examined from the study area. With regards to

species number in a family, the most dominant family is Poaceae (34 species), followed by Asteraceae (16 species), Fabaceae (14 species), Lamiaceae (nine species), Cyperaceae (eight species) and Polygonaceae (seven species) (Table 1). On the other hand, the remaining families in the study areas are comprise 3, 2 or 1 species each (Table 5). Twenty eight of the families (82.35%) belong to dicot and six families (17.65%) to monocot groups.

Tahtay and Lalay Maichew districts contain 6 endemic species of herbaceous plants (Table 2). Two of them are strict endemic to Ethiopia while four are endemic to Ethiopia and Eritrea, and called near endemic.

*TU=Tigray, HA=Harerge, SU= Shewa, GD=Gondar, WG=Welega, KF= Kefa, AR= Arsi, BA= Bale, WU=Welo, GJ=Gojam, IL= I1ubabor and GG=Gamo Gofa (Adopted from Flora of Ethiopia and Eritrea)

Identification of Plant Communities

Four clusters were recognized using hierarchical cluster analysis of R.2.11.1 computer program (Figure 4). Clusters represent plant communities in Lalay and Tahtay Maichew districts. The following plant communities have been named by two dominant species based on higher synoptic values. Based on the analysis, four plant communities identified from the study area were *Tagetes patula-Solanum nigrum* community type (community 1), *Hygrophila schulli - Rhynchosia resinosa* community type (community 2), *Dactyloctenium aegyptium-Sonchus oleraceus* community type (community 3) and *Cyperus elegantulus-Gnaphalium rubriflorum* community type (community 4). Description of plant community types with their altitudinal distribution are given below.

Tagetes patula-Solanum nigrum community type

Tagetes patula-Solanum nigrum are main indicator species of the community type (Table 3). Dominant species in this community type are *Plantago lanceolata, Galinsoga quadriradiata, Euphorbia polycnemoides*, *Trifolium burchellianum*, *Ocimum americanum*, *Anagallis arvensis*, *Leucas martinicensis*, *Solanum nigrum* and *Xanthium spinosum.* This community type consists 23 quadrats (1, 2,3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 33, 36, 37, 42, 44, 45, 47 and 62) and 108 species and it is distributed between 2054 and 2303m a.s.l. The three large sized wild grasses; *Hyparrhenia rudis*, *H. hirta* and *H. rufa* are mostly found in this community type.

Hygrophila schulli - Rhynchosia resinosa community type

Hygrophila schulli and Rhynchosia resinosa are main indicator species of this community type (Table 3). *Cyanotis barbata*, *Spermacoce sphaerostigma*, *Plectranthus lanunginosus* (Figure 5), *Hypoestes forskaolii*, *Andropogon chrysotachyus, Harpachne schimperi* and *Cicer cuneatum* are the dominant species. This community type contains 17 quadrats (17, 18, 19, 20, 22, 23, 24, 25, 34, 38, 39, 43, 56, 55, 57, 60 and 63) and 92 species. This community type is distributed between 2158 and 2333 m a.s.l.

Dactyloctenium aegyptium-Sonchus oleraceus community type

Dactyloctenium aegyptium and Sonchus oleraceus are the main indicator species of the community type (Table 3). Dominant species in this community include *Cynodon dactylon* (Figure 6)*, Bidens macroptera*, *Aristida kenyensis*, *Lapeirousia abyssinic*, *Justicia ladanoides, Medicago polymorpha* and *Rumex nepalensis*. This community consists of 20 quadrats (5, 21, 26, 28, 29, 35, 40, 41, 43, 46, 49, 50, 51, 52, 53, 54, 59, 61, 64 and 65) and 108 species and it is distributed between 1992 and 2313 m a.s.l.

Cyperus elegantulus-Gnaphalium rubriflorum community type

Cyperus elegantulus and Gnaphalium rubriflorum are main indicator species of the community type (Table 3). *Cyperus rotundus, Cyperus renschii, Echinochloa colona* (Figure 7), *Scorpiurus muricatus, Argyrolobium ramosissimum*, *Cynodon aethiopicus*, *Erucastrum abyssinicum, Gnaphalium rubriflorum* and *Trifolium schimperi* are also dominant species of this community type. It contains five quadrats (27, 30, 31, 32 and 58) and 36 species. This community is distributed in altitudinal range between 1982 and 2270 m a.s.l.

Species richness and equitability

The richness and evenness of species in the four different communities from the study area was calculated using Mponela (2010) diversity index (Table 4). Communities I and III had the highest species richness while community IV exhibited the least species richness. The reason why community I and III have the highest species richness is that they are located in a relatively better protected area. Community II with the lower species richness is due to overgrazing because of the local people highly threatened the area for domestic animals rearing and agricultural expansion. Particularly community IV's lowest richness is due to that community IV is located in the moist areas. Those moist areas are dominted by *Cyperus rotundus.* Dominance of this single species may results lowest richness and diversity. Magurran, (1988) stated that the term diversityactually consists of species richness and

Table 1. Plant families with their genera and species distribution in the study area.

Family name	No. of genera	Genera in %	No. of species	Species in %
Acanthaceae	2	2.02	2	1.52
Amaranthaceae	2	2.02	2	1.52
Amaryllidaceae	1	1.01	1	0.76
Anthericaceae	1	1.01	1	0.76
Apiaceae	3	3.03	3	2.27
Asteraceae	15	15.15	16	12.12
Boraginaceae	1	1.01	1	0.76
Brassicaceae	1	1.01	1	0.76
Caryophyllaceae	1	1.01	1	0.76
Chenopodiaceae	1	1.01	1	0.76
Commelinaceae	2	2.02	2	1.52
Convolvulaceae	1	1.01	1	0.76
Cucurbitaceae	2	2.02	2	1.52
Cyperaceae	1	1.01	8	6.06
Euphorbiaceae	1	1.01	1	0.76
Fabaceae	8	8.08	14	10.60
Gentianaceae	1	1.01	1	0.76
Geraniaceae	3	3.03	3	2.27
Iridaceae	1	1.01	1	0.76
Lamiaceae	6	6.06	9	6.82
Malvaceae	3	3.03	3	2.27
Nyctaginaceae	1	1.01	1	0.76
Oxalidaceae	1	1.01	1	0.76
Papaveraceae	1	1.01	1	0.76
Plantaginaceae	1	1.01	1	0.76
Poaceae	21	21.21	34	25.7%
Polygonaceae	5	5.05	7	5.30
Primulaceae	1	1.01	1	0.76
Resedaceae	1	1.01	1	0.76
Rubiaceae	3	3.03	3	2.27
Scrophulariaceae	2	2.02	2	1.52
Solanaceae	3	3.03	3	2.27
Verbenaceae	1	1.01	1	0.76
Vitaceae	1	1.01	1	0.76
Total	99	100	132	100

relative abundance (evenness). From the four communities distribution (equitability or evenness) community II has the highest species evenness and community I has the least species evenness, while the other communities (communities III and IV) have intermediate evenness. The communities showed some dynamics in species richness and eveness. The main causative agents for the dynamism of the communities are anthropological activities such as overgrazing by domestic animals. In general, the probable reasons for the variability of richness between the four community types arise from altitude, degree of disturbance involved in the area, cover abundance value and other environmental factors (slope, soil and aspect) which were not included in this study.

Where: I =*Tagetes patula-Solanum nigrum community type*

II= *Hygrophila schulli - Rhynchosia resinosa* community type

Table 2. Endemic species found in Lalay and Tahtay Maichew districts, their families and distribution in Ethiopia.

Endemic species	Family	Distribution in Ethiopia*
Aeollanthus abyssinicus Hochst. ex Benth.	Lamiaceae	TU, GD and WG
Bidens macroptera (Sch.-Bip. ex Chiov.) Mesfin	Asteraceae	TU, GD, GJ, WU, SU, AR, IL, KF, GG, BA and HA
Erucastrum abyssinicum (A. Rich.) Schulz.	Brassicaceae	TU, SU, AR, KF, BA and HA
Indigofera rothii Bak.	Fabaceae	SU and HA
Lapeirousia abyssinica (R.Br. ex A. Rich Baker	Iridaceae	TU, GJ, WU and SU
Trifolium schimperi A. Rich.	Fabaceae	TU, GD, GJ, WG, WU, SU, AR and KF

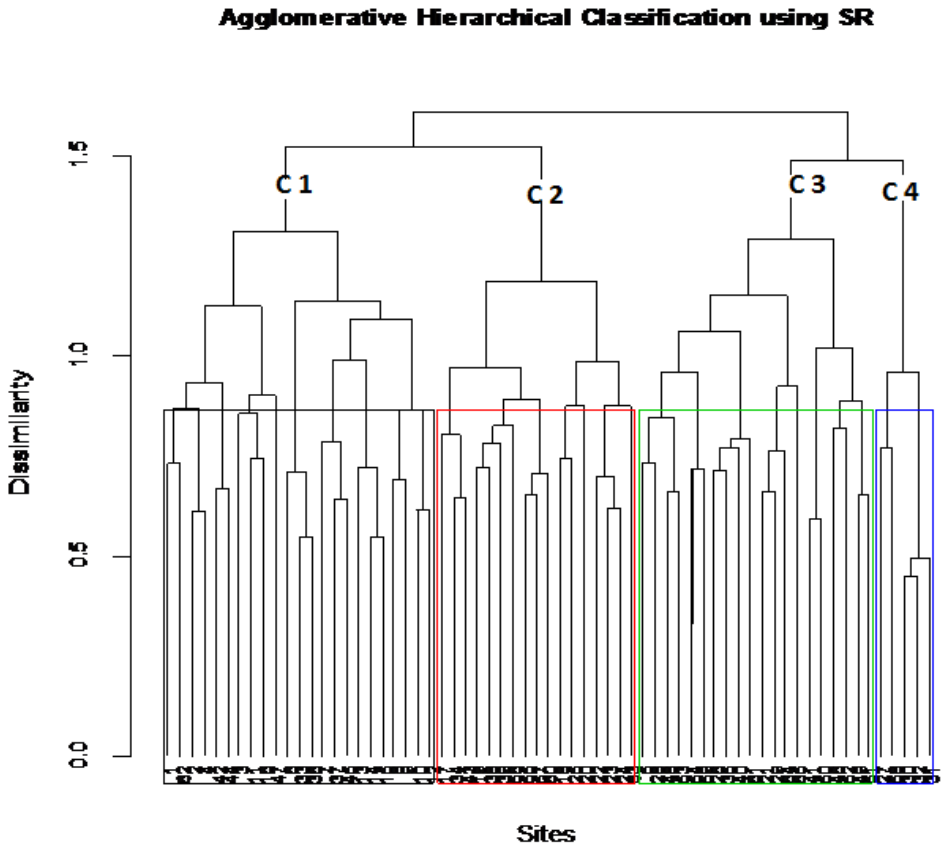

Figure 4. Dendrogram of the abundance of the 132 plant species and 65 quadrats from the study area (C 1 = Community 1; C 2 = Community 2; C 3 = Community 3 and C 4 = Community 4).
The plot code and arrangement of plot along the dendrogram from left to right are as follows:
C1: (Plots 1, 62, 2, 4, 42, 44, 3, 11, 16, 47, 6, 33, 36, 7, 37, 45, 13, 14, 15, 8, 9, 10 and 12)
C2: (Plots 17, 34, 43, 19, 38, 39, 56, 55, 57, 60, 18, 25, 20, 22, 23, 24 and 63)
C3: (Plots 5, 28, 48, 53, 54, 59, 26, 35, 40, 61, 21, 29, 64, 65, 41, 50, 46, 52, 49 and 51)
C4: (Plots 27, 58, 30, 32 and 31).

Table 3. Synoptic cover-abundance values of species having a value of > 0.25 in at least one community type and values in bold refer to occurrences with higher synoptic values or species with high degree of fidelity (the degree to which species are confined to particular group of quadrats).

Dominant species	Community1	Community 2	Community 3	Community 4
Cyperus elegantulus	0.00	0.00	0.15	**3.20**
Dactyloctenium aegyptium	0.00	0.00	**0.60**	0.00
Gnaphalium rubriflorum	0.17	0.00	0.00	**1.20**
Hygrophila schulli	0.00	**0.59**	0.00	0.00
Rhynchosia resinosa	0.00	**0.41**	0.00	0.00
Solanum nigrum	**1.17**	0.00	0.30	0.00
Sonchus oleraceus	0.00	0.00	**0.25**	0.00
Tagetes patula	**1.39**	0.47	0.00	0.00

Figure 5. Gobo Dura, Lalay Maichew dominated by *Hypoestes forskaolii* and *Plectranthus lanunginosus* (Photo by Genet Atsbeha).

III = *Dactyloctenium aegyptium-Sonchus oleraceus* community type and

IV= *Cyperus elegantulus-Gnaphalium rubriflorum* community type

Similarity among plant communities

Similarity between communities is calculated using the formula:

$$J = \frac{H'}{H'Max}$$

Where: J = Evenness H'= Shannon diversity index H' max=lnS

S = the number of species and ln = log base$_n$

Accordingly, Communities I and III have the highest similarity ratio (Table 5) followed by Communities I and II and Communities II and III respectively. The least similarity was exhibited between communities I and IV (Table 5).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

This study contributes the basic data on floristic composition

Figure 6. May Brazio, Tahtay Maichew dominated by *Cynodon dactylon, Bidens macroptera* and *Medicago polymorpha* (Photo by Genet Atsbeha).

Figure 7. Around Dura dam, Lalay Maichew dominated by *Cyperus elegantulus* and *Echinochloa colona* (Photo by Genet Atsbeha).

of herbaceous flowering plant species that provide base line information for ecological and studies. Results confirmed that 132 species of herbaceous flowering plants were collected and identified belonging to 99 genera and 34 families: which were identified from 65 quadrats examined from the study area. With regards to species number, the most dominant family is Poaceae (34 species). This is followed by Asteraceae (16 species), Fabaceae (14 species), Lamiaceae (nine species), Cyperaceae (eight species) and Polygonaceae (seven species). The study revealed that among 132 species six of the herbaceous flowering plant species are endemic to Ethiopia and Eritrean flora area, two of the six herbaceous flowering endemic plants are belong to the family Fabaceae and Asteraceae, Lamiaceae, Brassicaceae and Iridaceae contains one spies each. Two of the six endemic species are strictly endemic to Ethiopia where four are endemic to Ethiopia and Eritrea.

The vegetation was clustered in to four herbaceous flower-

Table 4. Richness, Diversity and Evenness.

	Richness	H' (Shannon diversity index)	Shannon Evenness
I	108	4.165238	0.887855
II	92	4.055754	0.896936
III	108	4.168028	0.890199
IV	36	3.230179	0.894559

Table 5. Similarity among plant communities.

Communities	Similarity	Altitudinal ranges (m a.s.l)
I, II	0.4565217	2054-2303/2158-2333
I, III	0.4791667	2054-2303/1992-2313
I, IV	0.3142857	2054-2303/1982-2270
II, III	0.4285714	2158-2333/1992-2313
II, IV	0.3191489	2158-2333/1982-2270
III, IV	0.3271028	1992-2313/1982-2270

ing plants community types which had different degree of species richness, diversity and evenness. Based on the out puts of the R.2.11.1 computer program the community types that were identified under the current study are *Tagetes patula-Solanum nigrum* community typ, *Hygrophila schulli - Rhynchosia resinosa*, *Dactyloctenium aegyptium-Sonchus oleraceus* and *Cyperus elegantulus-Gnaphalium rubriflorum* community types. The distributions of these plant communities in the study area were influenced by various environmental factors and biotic stresses which are operated in a combined way; this is why variations in species richness, composition and species diversity among communities could exist.

These findings corroborate the findings by earlier workers (Abate, 2003; Haile et al., 2008 and Lema, 2011). The result attained demonstrates that Lalay and Tahtay Maichew districts verify that a minimum of 132 herbaceous flowering plant species when compared with Donkoro Forest Abate (2003) Bale Mountain National Park Haile et al. (2008) and Menagesha Suba State Forest Lema (2011). Lalay and Tahtay Maichew districts contain the highest herbaceous flowering plant species richness. This is due to that Lalay and Tahtay Maichew districts covers total area of 60,500 km^2. However Bale Mountain National Park, Donkoro Forest and Menagesha Suba State Forest each cover approximately 2,200 km^2, 355.75 km^2 and 92.48 km^2 respectively. The similarity with , Bale Mountain National Park, Donkoro forest and Menagesha Suba State Forest is 9.92%, 11.86% and 8.50% respectively. Another reason for the richness of the districts in herbaceous species may be due to the distraction of woody plants allowing more space when compared with the forests. This similarity show that the similarity between Tahtay Maichew districts and the above four Forests is low. This similarity and differences could attribute to their degree of protection from grazing and human interference, geographic proximity, climatic zone, altitudinal range etc.

RECOMMENDATIONS

Plant species are the potential stock for future genetic resources, and would have great implications for the environment and biological diversity. Based on the results of the study, the following recommendations were drawn.

- ❖ It is better to plan areas to serve as endower sustainable bases to conserve these herbaceous flowering plants species specially the wild grasses such as using by cutting with a sickle rather than uprooting.
- ❖ It is recommended that the big stemmed wild grasses such as *Hyparrhenia rufa* and *Panicum maximum* need further check.
- ❖ The present study is limited to herbaceous species composition then further studies on, environmental parameters, protected areas management and conservation system and soil seed bank are recommended.

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