International Research Journal of Biological Sciences ISSN 2278-3202
Vol. 6(2), 5-15, February (2017) Int. Res. J. Biological Sci.

Diversity of vascular epiphytes in wondo genet natural forest, Southern, Ethiopia

Erchafo Mohamed*, Mulugeta Kebebew and Tesfaye Awas
Department of Biology, Arba Minch University, P.O. Box 21, Arba Minch, Ethiopia
erchafomohamed1@gmail.com

Available online at: www.isca.in, www.isca.me
Received 27th December 2016, revised 8th February 2017, accepted 10th February 2017

Abstract

This study was conducted to investigate the diversity of vascular epiphytes in Wondo Genet Natural forest, SNNPRS at altitude of 1750-2097m. Systematic sampling method was employed during data collection. Thirty six sample plots (20x20m) were laid and 400m between transect. All vascular epiphyte species found in each plot were recorded, collected, pressed and identified. Data was analyzed by using Micro soft Excel, TWINSPAN, CANOCO, PAST and SPSS programmes to distinguish the degree of diversity, distribution of species and community among different quadrants. A total 19 vascular epiphytes belonging to 7 families: Orchidaceae, Aspleniaceae and Polypodiaceae are dominant families of vascular epiphyte. The analysis by TWINSPAN, there are three plant associations and the result of ordination represents the presence of association of high Eigen value (0.753) and separated by long gradient (6.309 S.D. units) and Eigen value of 0.578 with gradient of 3.790 S.D units and Low Eigen value (0.411) and short gradients (3.067 S.D. units). The diversity of vascular epiphyte was influenced by phorophyte and diversity increases from base to canopy. More DBH host tree carries more epiphyte. Tree bark texture has an effect on diversity of epiphytes (rough bark texture of the phorophytes has more support epiphyte than smooth barked). Increasing altitudes, decrease diversity of epiphyte due to moisture and go from lower altitude to higher altitude sparsety of forest increases. Most epiphyte was not host specific. An old and large tree (Ficus vasta, Calpurina aurea, Celtics africana and Cordia Africana) has an effect on number of epiphyte diversity.

Keywords: Diversity, Host specificity, Phorophyte, Vascular epiphyte, Wondo genet natural forest.

Introduction

There are in fact up to 25000 species of vascular epiphytes alone that occur mainly in tropics[1]. epiphytes forms a major component of the diversity of tropical forests[2,3]. The shrub layer epiphytes are normally dependent on large mature trees that have up on them an abundant epiphyte community, which feds the shrub layer below with seeds and asexual plant material, those role it to colonize the substrata[4] .Vascular epiphytes share little quality beyond occurrences in tree crown that identity the mass a single ecological type, primarily because their phylogenic origins and their life style in forest canopies are diverse[5].

Epiphytes are extremely important element of the flora (they represent about 10% of all plant species globally)[6]. Epiphytes are responsible for much of the biotic diversity that makes humid tropical forests the most complex of all worlds terrestrial ecosystems[1].

Vascular epiphytes provide specialized services to the ecosystem functioning. The ecological services include: substrate and food for many canopy dwelling animals, indicator for conservation initials and indicator of air quality[7] , nutrient and water cycling[8], bioindicator to assess forest continuity[9], maintenance of the moisture of the environment[10], bioinicator of ecological damage[11], and contribute for plant species richness (biodiversity).

Epiphytes have also been used extensively for medical, agricultural and horticultural purposes for human being[11].

The diversity and distribution of vascular epiphytes are determined by many factors. The biophysical environment of phorophytes such as host size, bark texture, vertical stratification as well as elevation above sea level are among the major factors that determined diversity of vascular epiphytes. Vertical distribution of epiphyte indicated that diversity increases from the base of the host plants through trunk to the tree crown. However, species richness of vascular epiphytes was thought to decrease with increasing elevation[12]. Large trunks have more surface area to be colonized by epiphytes than small trees[13]. Rough bark texture of the phorophytes is similarly more convenient for vascular epiphyte species establishment than smooth ones[14]. Epiphytes are mostly abundant on forks, horizontal branches and rough barks of the host trees, but least abundant on vertical and smooth branches[15].

High diversity and distribution of vascular epiphytes variation are dominant among the tropical forest regions. According to[16] have published that, the tropical forests of Africa are generally poorer in species composition and diversity compared to the other continents. This condition may be due to the strongly influenced by human interference (high deforestation rates) and various degrees of disturbances made by human activities in the African countries. This appeared to prevent the potential diversity and succession the of epiphyte community.

The study of epiphyte diversity and distribution is yet not undertaken for many Ethiopian forests; except some reports from the study of vascular epiphytes in Harenna forest of Bale Zone of Oromia Regional State, the study of Home garden coffee as a repository of epiphyte biodiversity around Bonga Town, southwest Ethiopia and ecology and diversity of vascular epiphyte in Yayu Forest in Illu Ababor. The present study may be part of our trial that attempted to study vascular epiphytes in Wondo Genet Natural Forest. Thus, investigation of these ecologically important parts of our forests should not be taken aside. The present study was aimed to document taxonomic diversity and composition of vascular epiphytes in Wondo Gent Natural forest, SNNPNRS, Ethiopia.

Materials and methods

Description of the study area: Wondo Genet, is found in Sidama Zone, SNNPR State, located on the eastern escarpment of the central rift valley of Ethiopia, that extend between $7^0$06' N and $38^0$37' E, altitude of 1720-2620 m a.s.l., about 272 km south of the capital city, Addis Ababa and about 24 km east of Hawassa Town[17]. The total area of the Wereda is 15,145 ha or 151.45 km^2. Of this 6298.62 ha is for agriculture, 556.11 ha for grazing, 1106.84 ha covered by forest, 350 ha is said to be fertile and 160.2 ha is infertile areas. The topography of the Wereda has mountains and hills are covered 43.5%, flat areas 36.25% and undulating parts covere 20.25% of the wereda. The Wereda is bordered with Oromia Region in the North, Melga Wereda in the East, Habela Tula Kifle Ketema in the South and Oromia in the West (Figure-1).vegetation is Moist Afromontane forest located on the mountains along the eastern escarpment of the Ethiopian rift valley in the south. The forest is a remnant forest home for a diversity of plant and animal life (particularly birds and butterflies)[18].

National Meteorological Service Agency showed that the range of mean monthly minimum and maximum temperature of the study area are 10.2^0C and 30.1^0C in the month of December and February respectively. The hottest month is February with a maximum temperature of 30.1^0C and the coldest month is December with a minimum temperature of 10.2^0.

Research design: A reconnaissance survey was selected as a sample based on accessibility and the presence of epiphytes. Sampling method employed was systematic sampling method. Thirty-six, 20x20m quadrants were laid out systematically based on vegetation type in the study site. All vascular epiphytes were recorded on all host trees with diameter at breast height (DBH) >10cm found in all plots. Each host tree was divided in to three vertical zones namely: - Basal (from ground to dbh), Trunk (from dbh to first branch) and Canopy (from first branch to the tip of the tree)[19].

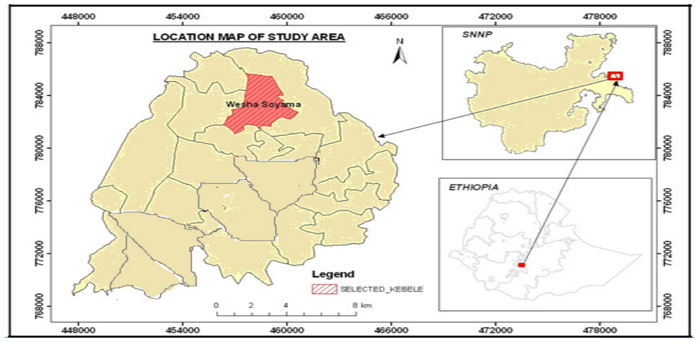

Figure-1: Map of the study area.

Methods of data collection: The activities during fieldwork were: measuring the diameter at breast height (DBH) of phorophytes, counting and sampling species of vascular epiphytes and bark texture and elevation, the abundance, and the exact location on the phorophytes were determined. All tree species with DBH ≥ 10 cm were considered appropriate host for sampling epiphytes. Because, phorophytes with dbh less than 10 cm have smaller surface area and thus hold either very few number or no vascular epiphyte species.

Qualitative data such as; presence/absence of all vascular epiphytes occurring on host plants rooted inside the plots was recorded. Sample specimen of both vascular epiphytes and phorophyte were collected and pressed in the flied. Sampling of epiphyte species was done by using binoculars for well developed epiphyte occurring high up in the canopies and with the help of indigenous climber for other parts of the trees which was the most important method used for observation and specimen collection.

The number of vascular epiphytes on each phorophytes was counted. Those epiphytes occurring in dense stands such as *Peperomia abyssinica* and *Drynaria Volkensii* were counted as one individual[11,16]. The census effort among host trees was standardized by recording the time taken to inventory each tree and after all epiphyte species inhabiting each tree were recorded, a further search was made for one-third of the time already spent searching. As a new species is encountered during this time, an additional one-third of the total survey time was again spent searching in an attempt to ensure an adequate, consistent survey of each tree. Next, complete inventories of several host trees from a canopy-walkway to identify the accuracy of ground-based surveys were conducted[20].

Data analysis: The voucher specimens of both phorophytes and epiphytes with their reproductive parts were collected and pressed in triplicates. Only, small parts of the phorophytes plants with their leaves and reproductive organs were used in order to fit with the size of the pressing material. However, the whole plant was used in the case of epiphytes. Then, the specimen was properly; pressed, dried and identified using published literatures (Flora of Ethiopia and Eritrea) and herbaria specimen in the Addis Ababa University. The relationship between number species of epiphytes and host size and elevation were analyzed by using a computer software program known as SPSS and PAST- Paleontological Statistics, version.1.56 [21]. For classification and association of plant species a computer software program TWINSPAN, version 1.0 was used[22]. Although there are some critics on the method[23], it is a useful tool both in scientific research and in nature management and conservation[24]. This analysis by TWINSPAN was performed by conserving the species cover or abundance in to ordinal transform values (OTV) of scale 1-9 based on[25]. TWINSPAN produce a tabular matrix arrangement that indicates plant community association. The final tables present both classification and an ordination of the plants. The resulting groups were recognizing as association.

Host specificity of the epiphytes is also analyzed by using qualitative data recorded during field collection. The control of textures (i.e., host size and bark textures) phorophytes on the diversity of epiphyte species per tree was compared and described qualitatively. Also vegetation ordination analysis was run by using Detrended Correspondence Analysis (DCA) with CANOCO soft ware (version 4.5)[26].

Results and discussion

Species diversity of vascular epiphytes: A total of 19 species of vascular epiphytes belonging to 7 families have been recorded from the study sites (Figure-2). Almost all of the identified species are holoepiphyte and the dominant family is Orchidaceae, Aspleniaceae and Polypodiaceae followed by Piperaceae and Pteridaceae whereas Dryopteridaceae and Amaranthaceae are the least abundant. In contrast to this finding[27] recorded 55 species of vascular epiphytes belonging to 35 families and the most species rich family is Aspleniaceae. The difference in species diversity of vascular epiphytes recorded by above author and the high diversity of Orchidaceae in the study area may be related to its characteristics high stress tolerance and its adaptive traits[28]. Reported that, Adaptation of orchids to temporary water stress and their ability to grow in drier and more-sun exposed areas of the upper canopy irrespective of the forest types make them inappropriate indicators of disturbances.

Classification: The vegetation classification (Table-1) from TWINSPAN-Two-way Indicator Species Analysis, the plant associations valid by the analysis. The species on the top (association one) are abundant on the left side of the primary division. The species on the bottom (in association three) are abundant on the right side of the primary division. The species in the middle (association two) are almost constant, which was happening over large range on both sides. This naming of the association was based on fidelity, depending up on the degree to which a species is limited to a definite association. A species occurring in more than 60% in the given relevés of a particular association is and so called indicator species[22]. Almost all are constant; TWINSPAN used two species, *Celtics africana* and *Ficus vasta* as an indicator species to determine the group of samples to the division both hand side (association two).

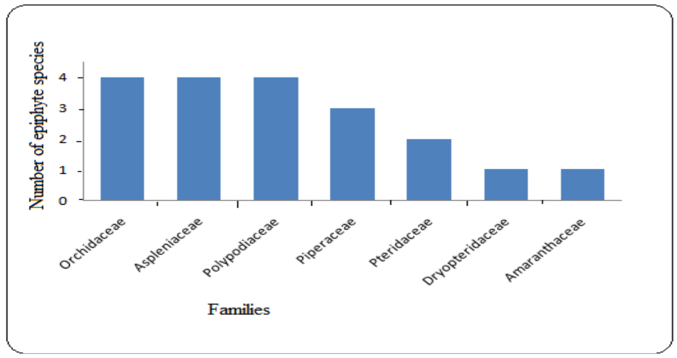

Figure-2: Vascular epiphytic richness by families of Wondo Genet Natural Forest.

Most of the species in association two are trees, except some epiphytic species such as *Asplenium bugoiense, Peperomia tetraphylla, Tectaria gemmifera, Pteris dentate*, *Habenaria armatissima* and *Angraecopsis trifurea.* When the association between epiphytes and their phorophytes were obtained, *Asplenium bugoiense* with *Calpurina aurea* were associated together. Two epiphytic species, *Peperomia tetraphylla* and *Tectaria gemmifera,* both were associated to *Olea welwitschii.* Although another epiphytic species such as *Acyranthes aspera, Habenaria armatissima* and *Angraecopsis trifurea,* both were association with *Ficus vasta* and also, association with *Pteris pteridiodes* was analyzed.

From the TWINSPAN result of Table-1, now, conclude that selective cutting of some important species such as indicator species (host trees) will resulted in total loss of their respective epiphytic plants. However, selective cutting of important host of *Calpurina aurea* may eventually the way to loss of epiphytic species called *Asplenium bugoiense.* Cutting of *Olea welwitschii* and *Ficus vasta* may indicate that the highest (potential) loss epiphytic species include *Peperomia tetraphylla and Tectaria gemmifera* and as well as *Acyranthes aspera, Habenaria armatissima, Angraecopsis trifurea* and *Pteris pteridiodes,* respectively. From association one and association three, can conclude that, epiphytic species are not seen but only one epiphytic species called *Asplenium theciferum* that are found in *Euclea divinorum* in association one.

Distribution and diversity of Vegetation in the study Area by Ordination: The Distribution and diversity of vegetation in the study area was analyzed by using Detrended Correspondence Analysis with computer program CANOCO (Figure-3) and prior to running of the data by using this program. The data set consisting of 64 species in the 36 plots were used in the final ordination. This was run to analyze patterns of variation in the species composition. The similar grouping of sample plots were seen as that of TWINSPAN from DCA result and both were computed by species occurrences and abundance in the sample plots.

Table-1: The ordered two-way table from TWINSPAN showing the association of epiphytes

Species	Sample plots			Association
	2222222	12--1111-1----1111--	332332333	
	0247368	47818926475112365039	039125465	
8 **Aspl thec**	22-----	--------------------	---------	Association One
25 Eucl divi	--2--22	--------------------	---------	
30 Grev robu	----2--	--------------------	---------	
33 Hipp goet	22--3--	--------------------	---------	
48 Phyt dode	---222	--------------------	----------	
59 Term brow	-331---	--------------------	---------	
7 **Asple bugo**	-------	3--3----------------	---------	Association Two
12 Calp aure	-------	-----2--------------	---------	
17 Chas disc	-------	----------231-------	---------	
40 Mayt grac	-------	---------12-----1---	---------	
41 Mimu kumm	-------	2----33-3------2----	---------	
42 Olea welw	-------	-1--1---------------	---------	
46 **Pepe tetr**	-------	----2---------------	---------	
58 **Tect gemm**	-------	-33-----------------	---------	
61 Urer hyps	-------	------2-----------1-	---------	
62 Vepr dain	-------	---3--3223---------	----------	
20 Crto macr	-------	2--21------22--2-	--------- --	
64 Vern aurc	-------	2-2----1--------2---	---------	
16 Celt afri	-------	---32222----2333-233	---------	
21 Delb lact	-------	--------1---------1-	---------	
34 Just schi	-------	2--2-----------2---2	---------	
51 **Pter dent**	-------	---------3-------3--	---------	
28 Ficu vast	-------	1---------1-212-----	---------	
3 **Acyr aspe**	-------	------------1-------	---------	
31 **Habe arma**	-------	----------------3--1	---------	
5 **Angr trif**	-------	-------------2---2--	---------	
10 Budd daui	-------	--------------------	--33-----	Association Three
13 Cant seti	-------	--------------------	--3-2--2-	
14 Cari spin	-------	--------------------	-222-----	
43 Onco spin	-------	--------------------	3333323--	
2 Acok schi	-------	--------------------	------122	
9 Bers abys	-------	--------------------	-1----132	
15 Cass malo	-------	--------------------	-------2-	
32 Hipp afri	-------	--------------------	-----2-2-	

The first DCA axis represents the long gradient (6.309 S.D. units) and high eigenvalue (0.753). This gradient separated the Moist Afromontane forests on left hand side association one by *Euclea divinorum* and *Celtics africana* on the association two in the ordination plot. The second DCA axis 3.790 S.D units and eigenvalue of 0.578 separated the *Ficus vasta* dominated Moist Afromontane forests (association-2) from *Oncoba spinosa* dominated Moist Afromontane forests (association-3). The third DCA axis is not much presented as they had low eigenvalues 0.411 and short gradients 3.067 S.D. units.

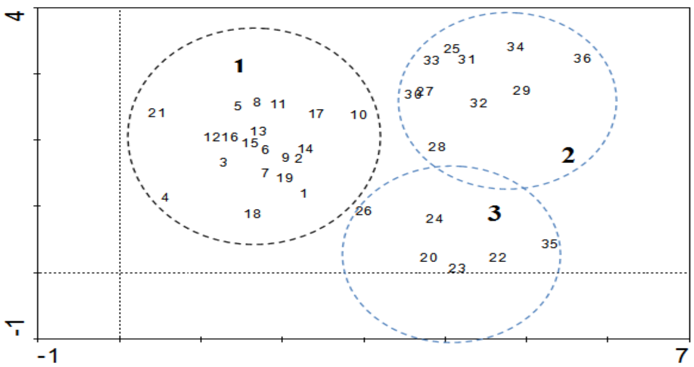

Figure-3: DCA ordination plot valid by running CANOCO, axis 1 (horizontal) and axis 2 (vertical). Axis is scaled in S.D. units. Circles represent the association where as number represent sample plot. Bold numbers in circles represent the association identified by using TWINSPAN.

Vertical distribution of vascular epiphytes on host Zones: Differences in the pattern of vertical distribution of vascular epiphyte are found on different zones of their host plant species. While richness of vascular epiphyte species increased in the order of base-trunk-canopy regions in Wondo Genet Natural forest (Table-2). Three species of vascular epiphytes namely *Drynaria Volkensii, Peperomia abyssinica* and *Peperomia fernandopoiana* are distributed throughout its host zone (Table-2). *Angraecopsis trifurea, Asplenium sandersonii, Asplenium theciferum, Habenaria armatissima, Lepisorus excavates, Loxogramme abyssinica, Peperomia tetraphylla* was observed from two host zones. Nine species namely *Asplenium bugoiense Pteris dentate, Pteris pteridiodes, Tectaria gemmifera, Asplenium aethiopicum, Disa aconitoides, Polystachya steudneri, Acyranthes aspera* and *Loxogramme abyssinica* found to grow one phorophyte zones. This difference may be depends up on different factors like surface area and exposition to different environmental disturbance. According to Abuna Tafa[29] some vascular epiphytes are not restricted only base or trunk and canopy, so this is similar with my founding.

Most of the epiphytes species are found on canopy of tree and large stems. Vascular epiphytes (*Asplenium aethiopicum* and *Polystachya steudneri)* were only growing in the canopy region. These due to crown species may be regarded as better adapted to drier conditions and high irradiance as vascular epiphytes that inhabit the upper canopy are suggested to prefer low moisture and high light requirements[30]. Three vascular epiphytes namely *Asplenium bugoiense, Loxogramme lanceolata* and *Pteris dentate* were restricted only in the basal region.

Generally, from above, the most of epiphytic species abundantly distributed over the middle zone and canopy of their host plants. In a similar manner Pos E.T. et al[31] in their study of vascular epiphytic plant ecology of Brazil Nation forest stated that, the least number of epiphytic plant species was recorded from the basal area. The reason for the least number of epiphytes from the basal area of the host plant may be branches in the canopy that prevent sunlight and also easily disturbed by animals.

Host specificity of vascular epiphytes: Most vascular epiphytic species were not host specific. Most of vascular epiphyte is registered from two or more host tree species. 94.7% of the epiphyte was recorded from two or more host tree species but, one epiphyte species (Loxogramme lanceolata) which is 5.3 % were recorded from a single phorophyte species called *Olea welwitschii*. This is an agree with Tesfa Alemayehu[27]**,** in his study at Harenna Forest of Bale, Ethiopia and Abuna Tafa[29], in his study at Yayu forest of southwest oromia, Ethiopia reported that (90.9 % and 86.1%), respectively were not host specific. Eventhough, the vascular epiphytes (*Asplenium bugoiense)* was recorded from 4 different phorophyte species[32] reported that, epiphyte species had significant preferences for one or two host tree species. According to Benzing D.H.[33], epiphytes occur on a number of different phorophytes, but with variable frequency.

Although, all phorophytes are not equally suitable for distribution of vascular epiphytes. In most phorophytes species are important to vascular epiphytes but others are less host contain vascular epiphytes. This may base on bark characteristics (rough), branch inclination and large size of host trees. In another way, the phorophytes (*Celtics Africana*, *Ficus vasta* and *Olea welwitschii)* are indicators species for hosting vascular epiphytes. This due to larger trees are essential determining of epiphyte diversity than small trees, because large trees are high water holding capacity, accumulation of nutrient and germination of seed. According to Hietz P.[7], trees with a rough bark are preferred hosts. Older host plants also have more possibilities for colonization from epiphytes[34]. Laube S. and Zotz G. reported that, each potential host tree species offers a different set of architectural traits: branch angles, diameters, chemical and morphological bark characteristics, and a microclimatic regime which suggests that there could be rather unique epiphyte assemblages on each host tree species.

Host species such as *Crton macrostachyus, Vernonia aurculifera*, *Vepris dainellii* and *Maytenus gracilipes* were contain less number of vascular epiphytes. According to Hietz P.[35], it was suggested that host species can affect epiphytes at least to the extent that some trees have suitable substrates and are densely colonized, whereas others are less suitable with only sparse epiphyte growth on them. According to Liu W.J.[36] and Trapnell D.W.[37] suggested that, there was no significant positive relationship between epiphyte species and hosts; this means that small host size that contains small number of epiphyte species.

Table-2: Vertical distribution of vascular epiphyte on host Zones

No	Epiphytes	Phorophyte zone		
		Basal	Trunk	Canopy
1	*Acyranthes aspera* L.	-	+	-
2	*Angraecopsis trifurea* (Rchb.f.) Schltr.	-	+	+
3	*Asplenium aethiopicum* (Burm.f.) Bech.	-	-	+
4	*Asplenium bugoiense* Hieron	+	-	-
5	*Asplenium Sandersonii* Hook.	-	+	+
6	*Asplenium theciferum* (Kunth.) Mett.	-	+	+
7	*Disa aconitoides* Sonder	-	-	+
8	*Drynaria Volkensii* Hieron	+	+	+
9	*Habenaria armatissima* Rchb.f.	-	+	+
10	*Lepisorus excavates* (Willd.) Ching.	-	+	+
11	*Loxogramme abyssinica* (Baker.) M.G.Price.	-	+	+
12	*Loxogramme lanceolata* (SW) Pers	+	-	-
13	*Peperomia abyssinica* Miq.	+	+	+
14	*Peperomia fernandopoiana* C.CD	+	+	+
15	*Peperomia tetraphylla* (Forester) Hock	-	+	+
16	*Polystachya steudneri* Rchb.f.	-	-	+
17	*Pteris dentate* Forssk	+	-	-
18	*Pteris pteridiodes* (Hook) Ballard	+	-	-
19	*Tectaria gemmifera* (Fee) Alston	+	-	-
Total		8	11	13

Base=ground to diameter at breast height (DBH), trunk=DBH to the first branch, and Canopy = first branch to the tip of the tree

Diameter at breast height (DBH) of phorophytes and diversity of vascular epiphytes: The data collected from phorophytes with different sizes and corresponding number of epiphyte species were analysis by using statistical package for the social sciences (SPSS) and a positive correlation was found between the number of epiphytes and phorophyte species. This show that DBH and number of epiphyte species are significantly and positively associated (r^2 = 0.693). The mean vascular epiphyte species count per phorophyte is 1.73 with standard deviation of 0.79 (N =11) (Table-3 and Figure-4). Similar results have been reported by different authors that, there is positive relationship between phorophytes and number of epiphyte species (number of epiphyte species increase with increasing sizes of phorophytes). According to Hietz-Seifert U. et al[38], the number of epiphytic species per tree was strongly correlated with tree size. The tree size relates to several factors that contribute to epiphyte establishment and larger trees are likely, on average, to be older, allowing more time to capture spores[39]. A significant positive relationship was found from the association between trunk size and epiphyte[36].

Table-3: The relationship between number of vascular epiphyte species and host DBH

	Description	DBH	Epiphytes
	Pearson correlation(r)	1	0.832
DBH	R Square	-	0.693
	Adjusted R Square	-	0.658
	Sig. (1-tailed)		0.001
	Std. Error of the Estimate	-	0.206
	Sum of Squares	0.383	0.863
	Covariance	-	0.007
Descriptive Statistics	**Mean**	0.64	1.73
	Std. Deviation	0.353	0.786
	N	11	11

Correlation is significant at the 0.05 level (1-tailed).

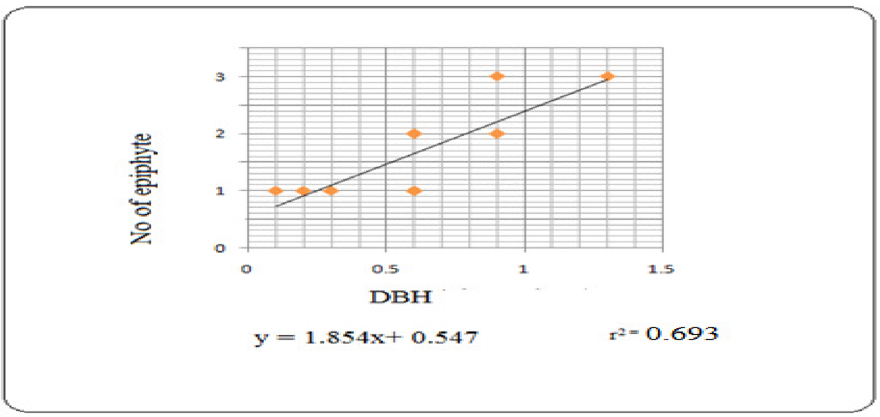

Figure-4: Relationship between DBH of phorophytes and number of vascular epiphyte species.

Bark texture of phorophytes and vascular epiphytes: Bark texture of host plants were analysis by based on observation. The bark texture of phorophyte was classified into two types, these are rough and smooth. Rough bark texture phorophyte species possessed 88.1% while smooth barked phorophyte species possessed 11.9% (Table-4). Thus, almost all vascular epiphytes recorded from rough barked phorophytes. This means, 18 (94.7%) were collected from rough barked phorophytes (Table-4). My result has been similar with some authors like[29], reported that, Most of the recorded phorophyte species (80%) possessed rough bark texture. According to Munoz A.A. et al[32], smoother texture of host bark could explain the lower epiphytic cover compared with rough textures of other tree species in the forest. The more textured the bark, the more substrate recesses available to catch seeds and accumulate nutrients. Such pockets and fissures harbor humus and retain moisture. Rough bark may characterize the colonization of epiphyte species in a host trees[40]. Age-related changes in bark structure and humus accumulation in the canopy create further diversification of the arboreal habitat[14]. In general; almost all smooth barks were not comfortable to diversity of vascular epiphytes. Bark substrate characteristics also are of primary importance to seedling recruitment. These include bark texture, whether the bark is stable or exfoliating, its water-holding capacity, porosity, and bark chemistry (pH, growth inhibiting exudates, and/or leachates. Phorophyte characteristics such as bark texture, branch inclination (Increased inclination is associated with reduced water, light, and nutrient accumulation), stand age, cardinal orientation and presence or absence of like latex, resins have factors that influence diversity of vascular epiphytes in the study area. The favorable bark characteristics, such as high water content and high water retention capacity are essential for more diverse and more abundant of epiphytes on host species. Bark thickness and water retention capacity is strongly correlated[41].

Table-4: List of vascular epiphyte existing bark textures of phorophyte

No	Species of epiphyte	Species of phorophyte	
		Rough	Smooth
1	*Acyranthes aspera* L.	+	-
2	*Angraecopsis trifurea* (Rchb.f.) Schltr.	+	+
3	*Asplenium aethiopicum* (Burm.f.) Bech.	+	-
4	*Asplenium bugoiense* Hieron	+	+
5	*Asplenium Sandersonii* Hook.	+	+
6	*Asplenium theciferum* (Kunth.) Mett.	+	+
7	*Disa aconitoides* Sonder	+	+
8	*Drynaria Volkensii* Hieron	+	+
9	*Habenaria armatissima* Rchb.f.	+	+
10	*Lepisorus excavates* (Willd.) Ching.	+	+
11	*Loxogramme abyssinica* (Baker.) M.G.Price.	+	-
12	*Loxogramme lanceolata* (SW) Pers	+	-
13	*Peperomia abyssinica* Miq.	+	+
14	*Peperomia fernandopoiana* C.CD	-	+
15	*Peperomia tetraphylla* (Forester) Hock	+	+
16	*Polystachya steudneri* Rchb.f.	+	-
17	*Pteris dentate* Forssk	+	+
18	*Pteris pteridiodes* (Hook) Ballard	+	+
19	*Tectaria gemmifera* (Fee) Alston	+	+
Total		18	14

Altitudinal distribution of vascular epiphyte: The sampled plots in the study area were laid between 1750 m-2097 m altitudinal ranges. High diversity of vascular epiphytes found around height of 1872 m-1976 m a.s.l. (medium elevation). Above 1976 m, there is a slight oscillation of distribution with general decreasing pattern of number of epiphyte along altitudinal gradient. However, the numbers of vascular epiphyte species existing at the extreme lowest and highest altitudes were equivalent, both with the least number of epiphytes. Some species were found distributed thought the altitudinal gradient where as some were restricted to the lowest altitudinal range and higher altitudinal range of the sampled area. The Aspleniaceae, Polypodiaceae and Piperaceae family were highly distributed within altitudinal range of 1750-2097m. However, Pteridaceae and Dryopteridaceae show greater variation with in altitude. This family was not observed in 1872-1976 m. *Loxogramme lanceolata* is only found at highest altitude with 1987-2097m and it is not observed at altitude of 1750-1865 m. This may be related with the absence of host species especially *Olea welwitschii* in the area. *Polystachya steudneri, Disa aconitoides and Acyranthes aspera* were restricted to the lowest altitudinal range between 1750-1865m and also it found in a very few number at this elevation. Also the result generated from PAST indicated the presence of strong negative relationship (r = -

0.6348) between altitudinal gradient and epiphytic composition (Figure 6). This founding is similar with some authors[29] and[27].

Generally based on the above result, altitude is one of the important environmental factors that govern species distribution. According to Cardelús L.C.[42] the likelihood of the elevational ranges of many species is higher at mid-elevations than for the lower and higher elevations and although mid-elevation richness bulge has been suggested for vascular epiphytes in general[43,44]. Supporting above view, [15] stated that, altitude is another factor that strongly influences the occurrence and distribution of vascular epiphytes on the phorophytes. Height above the ground and altitude above sea level are parameters always found to be important for epiphyte occurrence. Also another finding by Biedinger N. et al[45], Average number of vascular epiphytes on a single phorophyte decreases with increasing altitude. Not only this, but the study by[1] show that, in tropical rain forests, the vertical stratification with in canopy of epiphytes is correlated with gradients in humidity and the moisture availability of microhabitats that affects epiphyte distribution on individual phorophytes.

As indicated in Figure-6, shows that altitude is one of the environmental factors that measure diversity of vascular epiphytes[12], species richness was thought to decrease with increasing elevation.

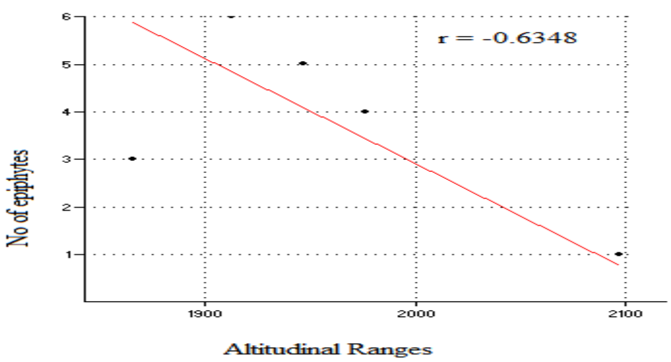

Figure-5: Altitudinal distribution of vascular epiphyte species in study area.

Conclusion

This study was envisioned to investigate diversity and distribution of vascular epiphytes in Wondo Genet Natural forests and within this study, total of 19 vascular epiphyte species was recorded which belong to 7 families were collected and identified. Orchidaceae is the most dominant and species rich family this may related to its characteristics high stress tolerance and its adaptive traits.

When compared with other tropical forest, species diversity of vascular epiphytes in the study area is low. This may relate to environmental factors like forest disturbance, bark texture of host, altitude and DBH that measure the diversity of vascular epiphytes. The result of this study demonstrated that epiphyte life tied to host plants that provide them mechanical support. The number of species is relatively higher on large tree and it decline as the height and size of host decrease. The distribution of epiphyte has shown an increasing trend from the stem to crown of phorophyte but decreasing from lower altitudes to higher altitude. Tree bark texture also influence the number of epiphyte species, in that rough texture support more epiphytes than smooth ones. The host size has an effect on number of epiphyte species; the large size of phorophytes, the more number of epiphyte species on it.

Forests are primary sources of diverse resources to local people whereas epiphytes are inconspicuous, rarely noticed, and less interest attracting components of the forest.

Therefore, all, the local community whose direct impact of disturbance may face should made awareness and practice sustainable use of natural resource and conservation management. Not only the local community but the government should equally worry about the disturbances of the natural resource.

Acknowledgements

We are grateful to thank Addis Ababa University (national herbarium) for helping during identification.

References

1. Zotz G. and Hietz P.(2001). The physiological ecology of vascular epiphytes: current knowledge, open questions. *J. Exper. Botany*, 52(364), 2067-2078.

2. Gentry A.H. and Dodson C.H. (1987). Diversity and biogeography of Neotropical vascular epiphytes. *Ann. Missouri Bot. Gard*, 74(2), 205-233.

3. Kelly D.L., O'Donovan G., Feehan J., Murphy S., Drangeid S.O. and Marcano-Berti L. (2004). The epiphyte communities of a montane rain forest in the Andes of Venezuela: patterns in the distribution of the flora. *J Trop Ecol*., 20(6), 643-666

4. Goddings H., Greenwood J. and Turnbull A. (2006). Vascular Epiphyte Diversity within the La Chonta Forestry Concession, Bolivia. *Project Bosque, University of Edinburgh and the University of Uppsala*.

5. Benzing D.H. (1987). Vascular epiphytism: taxonomic participation and adaptive diversity. *Ann. Miss. Botan. Gard.*, 74(2), 183-204.

6. Nieder J., Prosperi J. and Michaloud G. (2001). Epiphytes and their contribution to canopy diversity. *Plant Ecology*, 51-63.

7. Hietz P. (1999). Diversity and conservation of epiphytes in changing environment. lecture presented at the international Conference on Biodiversity and Biore- sources: Conservation and Utilization, *Pure Appl. Chem*, 70, 1-11.

8. Nadkarni NM. (1992). The conservation of epiphytes and their habitat; Summery of discussion at the international symposium on the biology and conservation of epiphytes. *Selbyana*, 13, 140-142.

9. Rolstad J., Gjerde I., Gundersen V.S. and Saetersdal M. (2002). Use of indicator species to assess forest continuity. *Conservation Biology*, 16(1), 253-257.

10. Benton A.H. and Werner W. (1966). Field Biology and Ecology. McGraw Hill inc. U.S.A., 180-181.

11. Barthlott W., Schmit-Neuerburg V., Nieder J. and Engwald S. (2001). Diversity and abundance of vascular epiphytes: a comparison of secondary vegetation and primary montane rain forest in the Venezuelan Andes. *J. Plant Ecol.*, 152(2), 145-156.

12. Stevens G.C. (1992). The elevational gradient in altitudinal range: an extension Rapaport's latitudinal rule to altitude. *Amer.Natur.*, 140(6), 893-911.

13. Zotz G. (1997). Substrate use of three epiphytic bromeliads. *Ecography*, 20(3)**,** 264-270.

14. Nadkarni N.M. (2000). Colonization of stripped branch surfaces by epiphytes in a lower montane cloud forest. Monteverde, Costa Rica. *Biotro*., 32(2), 358-363.

15. Hietz P., Hietz-Seifert U. (1995). Structure and ecology of epiphytic communities of a cloud forest in central Veracrucz, Mexico. *J. Veget. Sci.*, 6(5), 719-728.

16. Johansson D.R. (1974). Ecology of vascular epiphytes in West African rain forest. *Acta Phytogeogr. Suec*., 59, 1-129.

17. Wondo Genet Wereda Administration (2009).

18. Wondo Genet Agricultural and Rural Development Office Report (2008).

19. Mojiol A.R., Jitinu A.M., Adella A., Ganang G.M. and Nasly N. (2009). Vascular epiphytes diversity at Pusat Sejadi, Kawang forest reserve, Sabah, Malaysia. *J. Sust. develo.*, 2 (1), 121-127.

20. Burns K.C. (2007). Network properties of an epiphyte metacommunity. *Journal of Ecology*., 95(5), 1142-1151.

21. Ryan P.D., Harper D.A.T. and Whalley J.S. (1995). PALSTAT, Statistics for palaeontologists. *Champman and Hall, London.*

22. Hill M.O. (1994). DECORANA and TWINSPAN for Ordination and Classification of Multivariate Species Data: a new edition, together with supporting programs, in FORTRAN 77. Huntington, UK.

23. Belbin L. and McDonald C. (1993). Comparing three classification strategies for use in ecology. *Journal of Vegetation Science*, 4(3), 341-348.

24. Bruun H.H. and Ejrnaes R. (2006). Community-level birth rate: a missing link between ecology, evolution and diversity. *Oikos*, 113(1), 185-191.

25. Van der Maarel E. (2005). Vegetation Ecology. *Vegetation ecology*, 1-51.

26. Laube S. and Zotz G. (2006). Neither host-specific nor random: vascular epiphytes on three tree species in a Panamanian lowland forest. *Annals of Botany*, 97(6), 1103-1114. Doi: 10.1093/aob/mcl067.

27. Tesfa Alemayehu (2006). Diversity and ecology of vascular epiphytes in Harenna afromontane forest, Bale, Ethiopia. MSc. thesis, Addis Ababa University, Ethiopia

28. WALTER H. and MUELLER DOMBOIS D. (1971). Ecology of Tropical and Subtropical Vegetation. *Ecology of tropical and subtropical vegetation*, Oliver & Boyd, Edinburgh, 539.

29. Abuna Tafa (2010). Diversity of vascular epiphytes along disturbance gradient in Yayu Forest, southwest Oromia, Ethiopia. aau, MSc. thesis Addis Ababa University, Ethiopia

30. Bussmann R.W., Werner F. and Schaff A. (2000). Epiphyte diversity in a tropical mountain ecosystem: the example of Eastacion Scientific San Francisco. Ecuador Universitat Bayreuth, 1.

31. Pos E.T. and Sleegers A.D.M. (2010). Vertical distribution and ecology of vascular epiphytes in a lowland tropical rain forest of Brazil. *Boletim do Museu Paraense Emílio Goeldi, Ciências Naturais,* 5(3), 335-344.

32. Munoz A.A., Chacon P., Perez F., Barnert S.E. and Armesto J.J. (2003). Diversity and host tree preference of vascular epiphytes and vines in a temperature rainforestin southern Chile. *Austral. J. Bot*., 51(4)**,** 381-391.

33. Benzing D.H. (1990). Epiphytism: a preliminary overview. Vascular epiphytes. General biology and related biota (ed. P. S. Ashton, S. P. Hubbell, D. H. Janzen, A. G. Marshall, P. H. Raven & P. B. Tomlinson), 1-42. Cambridge University Press.

34. Bergstrom J.B. and Carter R. (2008). Host-tree selection by an epiphytic orchid, Epidendrum magnoliae, in an Inland Hardwood Hammock in Georgia. *Southeast. Natura*, 7(4), 571-580.

35. Hietz P. (2005). Conservation of vascular epiphyte diversity in Mexican coffee plantations. *Cons. Biol.*, 19(2), 391-399.

36. Liu W.J. and Xu H. (2005). Species diversity and spatial distribution of epiphytes in a montane moist evergreen broad-leaved forest. In: proceedings of 4th international canopy conference. Leipzig, Germany.

37. Trapnell D.W. and Hamrick J.L. (2006). Variety of phorophyte species colonized by the Neotropical epiphyte, Laelia rubescens (Orchidaceae). *Selbyana*, 27(1), 60-64.

38. Hietz-Seifert U., Hietz P. and Guevara S. (1996). Epiphyte vegetation and diversity on remnant trees after forest clearance in southern Veracruz, Mexico. *Biol. Cons.*, 75(2), 103-111.

39. Cummings J., Martin M. and Rogers A. (2006). Quantifying the abundance of four large epiphytic fern species in remnant complex notophyll vine forest on the Atherton Tableland. North Queensland, Australia. *Cunninghamia*, 9(4), 521-527.

40. Steege H. and Cornelissen J.H.C. (1989). Distribution and ecology of vascular epiphytes in lowland rain forest of Guyana. *Biotropica,* 21(4), 331-339.

41. 41 Mehltreter K., Flores A. and Garcia G.J. (2005). Host preferences of low-trunk vascular epiphytes in a cloud forest of Veracruz, Mexico. *J. Trop. Ecol.*, 21(6), 651-660.

42. Cardelús L.C., Colwell R.K. and Watkins J.E. (2006). Vascular epiphyte distribution patterns: explaining the mid-elevation richness peak. *J. Ecol.*, 94(1), 144-156.

43. Nieder J., Prosperi J. and Michaloud G. (2001). Epiphytes and their contribution to canopy diversity. *Plant Ecology,* 153**,** 51-63.

44. Wolf J.H.D. and Alejandro F. (2003). Patterns in species richness and distribution of vascular epiphytes in Chiapas, Mexico. *Journal of Biogeography*, 30(11), 1689-1707.

45. Biedinger N. and Fischer E. (1996). Epiphytic vegetation and ecology in central Africa forests (Rwanda, Zaire). *Ecotro.,* 2(2), 121-142.