Journal of Science and Inclusive Development Vol. 5, No. 2, DOI:10.20372/jsid/2023-252

Floristic composition and diversity of epiphytes in Farante Forest, Sodo Zuria District, Wolaita Zone, Southern Ethiopia

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Received: 08 February 2023; Revised: 16 June 2023; Accepted: 20 November 2023

Abstract

Although epiphytes play a significant role in the functioning of forest ecosystems, their ecological importance has often given less attention. The objective of this study was to assess the floristic composition and diversity of epiphytes in the Farante Forest. A total of sixty (25m x 25m) plots/quadrates were systematically laid. They were laid on the line transacts that were established in the Farante forest for vegetation for data collection. Phorophytes' vertical structure, diameter at breast height, bark texture, abundance of epiphytes and phorophytes, and elevation of each plot were collected as data. Voucher specimens of both epiphytes and phorophytes were collected for identification in the national herbarium of Ethiopia. Twenty-six (26) vascular epiphytes belonging to 22 genera and 10 families were recorded in Farante Forest. Polypodiaceae was the most abundant family. Acacia abyssinica, Ficus vasta, and Olea europaea subsp. cuspidata harbored the highest species richness of epiphytes. The relative distribution of epiphytes on the vertical structure of the phorophyte indicated 37% on the trunk, 36% on the canopy, and 27% on the base. The relative distribution of epiphytes on the texture of the phorophyte indicates 63% on a rough texture and 37% on a smooth texture. A significant ($p = 0.002$) and positive correlation ($r = 0.96$) were observed in the abundance of epiphytes and the size of the DBH of phorophytes. The diversity and evenness of epiphytes were 3.01 and 0.924, respectively, in the forest. The finding, therefore, confirmed the dominance of a few epiphytes harbored by a few host species, the highest epiphyte composition in the trunk zone, and the rough bark of phorophytes.

Keywords: Composition, Diversity, Epiphytes, Farante Forest, Phorophytes

Introduction

The natural vegetation of Sodo Community Conservation Forest is characterized by a mix of vegetation with dominant species such as *Albizia gummifera*, *Erica arborea*, *Croton macrostachyus, Premna schimperi, Maesa lanceolata, Rhamnus prinoides, Embelia schimperi*, *Juniperus procera*, *Hypericum revolutum*, *Carissa edulis, Rhamnus staddo, Syzygium guneense, Olea europaea, Phoenix reclinata*, *Podocarpus falcatus*, *Luxia cankesta,Pittosporum viridflorum*, *Erythrina abyssinica*, *Brucea antidysenterica*, *Arundinaria alpine*, *Ximenia americana*, *Bamboo*, *Vernonia amygdalin,* and *Prunus africana*. The three sub-types of vegetation have been identified as grassland vegetation, broad-leaf bushy vegetation, and ericaceous dominant vegetation (Friis et al., 2011).

Epiphytes are defined as plants rooting on the surface of tree trunks or branches without harming or parasitizing the host tree (Getaneh and Gamo, 2016; Zotz, 2013; Benzing, 2004). Epiphytes depend on physical support from their host plants (phorophytes). Schubert (1990) defined a phorophyte as a host plant used by an epiphyte for physical support. Epiphytes: those that spend their entire lives on the host plants are referred to as holo-epiphytes; those that are initially terrestrial and later become epiphytes are referred to as partial epiphytes or heme-epiphytes (Dutta, 2005).

Globally, vascular epiphytes comprise about 30000 species, which is about 10% of the earth's total vascular plants (Mohamed et al., 2017; Wang et al., 2016; Zotz, 2013), and most of them are limited to tropical and subtropical forests, where they may be the most diverse life form (Mohamed et al., 2017). However, epiphytes are very diverse in species composition, but only a few families are represented, and ferns and orchids dominate the epiphytic flora (Krömer et al., 2005; Gentry and Dodson, 1987).

The diversity and distribution of vascular epiphytes are determined by the biophysical environment of phorophytes (host size, bark texture, and vertical stratification), altitude, disturbance, and climate change. Large trunks of the Phorophytes have more surface area than small trees; rough bark textures are more convenient than smooth ones for vascular epiphyte species establishment (Dessalegn and Tesfaye, 2018; Nadkarni, 2000; Zoltz and Ziegler, 1997). The vertical distribution of epiphytes indicated that diversity increases from the base of the host plants through the trunk to the crown (Getaneh and Gamo, 2016).

Epiphytes are ecologically important groups of plants that contribute to forests by increasing species diversity, productivity, biomass, litter fall, and water retention. Moreover, epiphytes provide substrates for nitrogen-fixing bacteria, are used as bio-indicators, provide habitats and food to insects and birds, and are used by humans for medical, agricultural, and horticultural purposes (De la Rosa-Manzano et al., 2019; Getaneh and Gamo, 2016; Benzing, 1998; Nadkarni, 1992).

The floristic composition and contribution to total forest flora are known only for a very few forests (Markos and Tegene, 2022; Ingram et al., 1996), and documenting the epiphyte flora of tropical forests is comparatively poorly studied, probably due to their hardly accessible habitat (Kuper et al., 2004). As a result, there is a lack of noticeable information, like the exact number of vascular epiphytes, in Ethiopia due to a lack of enthusiasm to study epiphytes in Ethiopian forest ecosystems (Dessalegn and Tesfaye, 2018; Getaneh and Gamo, 2016; Alemayehu et al., 2010; Tafa, 2010). The aforementioned problems are similarly facing this study area. In addition to this, the influence of disturbance, vertical gradient, and bark texture of phorophytes on the composition of vascular epiphytes has not been studied in the area.

Therefore, the present study was conducted to assess vascular epiphytes composition, diversity and the effect of altitudinal gradient on distribution of epiphytes on phorophyte zone and bark texture.

Materials and methods

Description of the study area

The study was conducted in southern Ethiopia at Farante Forest, located in Gurumo Woide Kebele, Sodo Zuria District, Wolaita Zone. The forest is about 405km to the south of Addis Ababa, Ethiopia. It is situated at approximately 6°54°N 37°45°E (Figure 1) and covers an area of 126.67 hectares. The study area has a bimodal rainfall pattern, with a long rainy season from June to October and a short rainy season in March and April. The average annual rainfall and temperature are 1365mm and 15.10^{0}c respectively. Farante forest was a mountain range conservation area and its elevation extends up to 2400 m. a. s. l. The forest encompasses natural spring, rivers and Georges. The bamboo trees on both sides of the river give a natural beauty for the area. The natural community managed forest is highly diverse and dominated by various plant species (WVE, 2013) and the vegetation of study area is categorized as dry land mountainous forest.

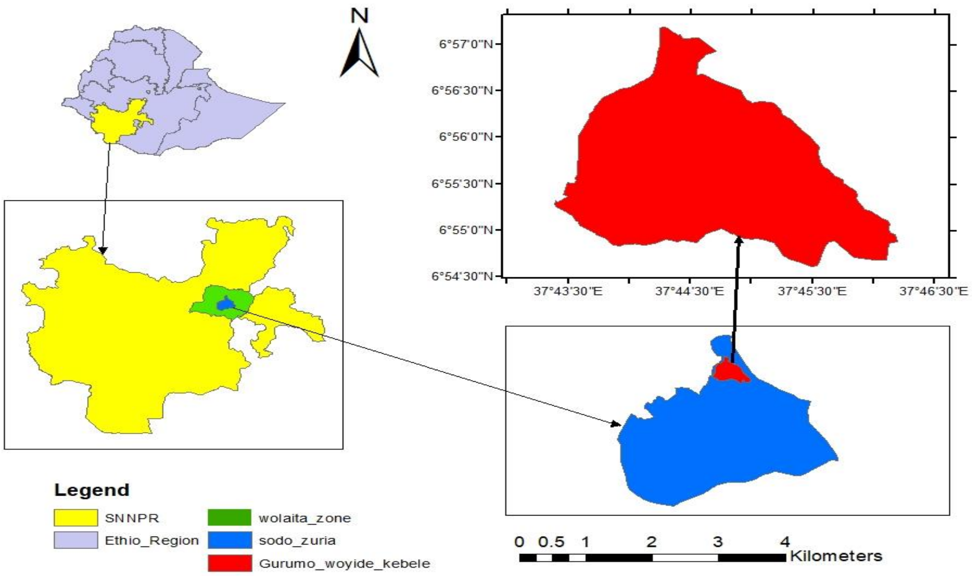

Figure 1: Map of the study area

Research design and data collection method

A reconnaissance survey was conducted from September 5–15, 2019 in order to obtain an impression of the site conditions, collect information on accessibility, and select a sampling site. A systematic sampling method was employed, and sixty (25m x 25m) quadrants were laid out on the transact line and systematically thrown. The sampled plots in the study area were laid between 2000 m and 2400 m altitudinal ranges.

The actual data collection was conducted from October 1 to November 30, 2019. During data collection, information on the DBH of phorophytes, the counting of vascular epiphytes, identifying bark texture types, and measuring elevation were determined. All vascular epiphytes were recorded from the basal (from ground to DBH), trunk (from DBH to first branch), and canopy (from first branch to the tip of the tree) (Mojiol, 2009) parts of host plant trees with a diameter at breast height (DBH) ≥2cm found in all plots. The life forms of the vascular epiphytes (true epiphytes (T), hemi-epiphytes (H), and accidental epiphytes (A) were identified according to Bogh (1992).

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Sample collection and recording of vascular epiphyte species were performed with the help of local assistants skilled in climbing trees, while counting the number of well-developed epiphytes occurring in the canopies or clusters was done with the aid of binoculars. Voucher specimens of both vascular epiphytes and phytophytes that were difficult to identify in the field were pressed and taken to the National Herbarium (ETH) for identification.

Data analysis

Before doing analysis, a normality test (Shapiro-Wilk) was done to check for outliers and reliability of the data. Horizontal distributions of vascular epiphytes were studied by assessing the phorophytes' presence or absence in each of the sixty sampling plots. In addition, for each phorophyte and epiphyte, species density, relative density, frequency, relative frequency, relative abundance, and Importance Value Index (IVI) were calculated. by using the methods described in Dallmeier et al. (1992).

Epiphyte plant species diversity was analyzed by the Shannon-Weiner diversity index, equitability (evenness), and dominance by the Simpsons' index. The Shannon-Weiner-Weinerity index varies between 1.5 and 3.5 and rarely exceeds 4.5. It is high when it is above 3.0, medium when it is between 2.0 and 3.0, and low when it is smaller than 1.0 (Kent and Coker, 1992).

As a measure of species diversity, we calculated the Shannon index (H′) using the following formula: $H' = -\sum_{i=1}^{s} \text{Pilnpi}$; Where is H′ = diversity of species; s = the number of species; Pi = proportion of individuals abundance of the i^{th} species; and ln = log base.

Simpson index (D) and evenness index (E = evenness) are used as a measure of species dominance and a measure for evenness of spread of species, respectively. As biodiversity increases, the Simpson index decreases. Therefore, compute $D' = 1 - D$ to get clear picture of dominance.

$D = \sum_{i=1}^{s} Pi^2$; Where is D = Simpson's dominance; s = number of species and Pi = proportion of individuals abundance of the i^{th} species

$E = \frac{H'}{\ln s}$; Where is E = Species evenness; $H' = \text{Shannon's index}$; s= number of species

The species evenness value ranges between 0 and 1. When it is 0, the area is dominated by a single species, and when it is 1, the species are evenly distributed in the area.

The distribution of vascular epiphytes along the altitudinal gradient and vertical stratification of phorophyte zones on different bark textures of the host plants were compared by the number of species registered in the area. Pearson's product-moment correlation analysis was applied to measure the linear relationship between the size of host plants (DBH) and the number of vascular epiphyte species, and Point-Biserial correlation analysis was the association that exists between a continuous variable (the number of vascular epiphyte species) and one dichotomous variable (phorophyte zone and phorophytes' bark texture). The correlation analysis was done by the NCSS 2022, v22.0.3 statistical package.

Results

Composition of vascular epiphyte

A total of 26 species of vascular epiphytes belonging to 22 genera and 10 families were documented in Farante Forest. Polypodiaceae was represented by 5 species (19%); Aspleniaceae, Lamiaceae, and Orchidiaceae were represented by 4 species each (15%); Asteraceae was represented by 3 species (12%); and Acanthaceae was represented by 2 species (8%), while the rest are scarce families (Moraceae, Euphorbiaceae, Hypolepidaceae, and Malvaceae) and represented by one species each (4% each) (Table 1). Epiphytes belonging to the family Polypodiaceae were distributed to 93 (35%) individuals of the phorophytes; Orchidiaceae were distributed to 69 (26%) individuals of the host plants; and Aspleniaceae were distributed to 54 (20%) individuals of the host plants. This finding has indicated that the species of Polypodiaceae can get access to more phorophytes than Orchidiaceae, but Aspleniaceae can get the least access than both families. Among families of epiphytes, the proportion of epiphytes distributing or getting on the surface of host plants is highest in Lamiaceae (5:1), followed by Aspleniaceae (14:1), Orchidiaceae (17:1), and Polypodiaceae (19:1), respectively (Table 1).

Table 1. Composition of vascular epiphyte

Epiphyte family	No. of epiphytes	Percent	No. of host plants species	No. of individuals of host plants	Proportion of distribution
Polypodiaceae	5	19%	18	93	19:1
Orchidiaceae	4	15%	13	69	17:1
Aspleniaceae	4	15%	10	54	14:1
Lamiaceae	4	15%	7	19	5:1
Asteraceae	3	12%	6	16	5:1
Malvaceae	1	4%	2	5	5:1
Moraceae	1	4%	2	2	2:1
Hypolepdiaceae	1	4%	2	4	4:1
Euphorbiaceae	1	4%	1	3	3:1
Acanthaceae	2	8%	2	4	4:1
Total	26		63	269	

The highest number of species of epiphytes (14) were distributed on each of *Acacia abyssinica*, *Ficus vasta*, and *Olea europaea* sub sp. cuspidata, followed by *Croton macrostachyus*, which harbored 13 epiphyte species; *Ficus sur*, *Cordia africana* and *Buddleja polystachya*, which harbored 12 epiphyte species each, but the least number of epiphytes (01) were distributed on *Ehretia cymosa* and *Vernonia amygdalina* followed by *Celtis africana*, *Ficus ovata*, *Terminalia schimperiana*, *Juniperus procera* and *Hagenia abyssinica* which harbored 3 epiphyte species each (Table 2). On the other hand, Polypodiaceae were distributed on a large number of phorophyte species, but Euphorbiaceae were distributed on a few phorophyte species.

The number of epiphyte species distributed on the phorophytes indicated that they are not specific to the specific species of the phorophyte. Besides, the phorophyte species with the highest number of epiphytes were the most preferred trees, with favorable bark texture and fewer disturbances than those with the least abundance of epiphytes.

Table 2. Composition and diversity of epiphytes on the selected phorophytes

Phorophyte species	Family	No. of epiphyte species grown on
Acacia abyssinica Hochste.	Fabaceae	14
Ficus vasta Forssk.	Moraceae	14
Olea europaea subsp. *cuspidate* L.	Oleaceae	14
Croton macrostachyus Del.	Euphorbiaceae	13
Ficus sur Forssk.	Moraceae	12
Cordia africana Lam.	Boraginaceae	12
Buddleja polystachya Fresen	Loganiaceae	12
Ficus ovata L.	Moraceae	3
Terminalia schimperiana Hohst	Comberataceae	3
Juniperus procera Hochst. ex Engl	Cupressaceae	3
Hagenia abyssinica (Bruce) J.F.Gmel	Rosaceae	3
Ehretia cymosa Thonn.	Boraginaceae	1
Vernonia amygdalina Del.	Asteraceae	1

Abundance of epiphytes along the Phorophyte zone

The relative distribution of species on the vertical structure of the phorophyte indicated that 37% of species were distributed on the trunk, 36% of species were distributed on the canopy, and 27% of species were distributed on the base part of the phorophyte. The composition of species was highest in the trunk zone, followed by the canopy and basal zone (Table 3). It was also confirmed that most of the species are not specific to the specific zone of the phorophytes, but a few species (*Phaulopsis imbricata* and *Ficus thonningii*) are specific to the trunk of the phorophyte. On the other hand, no epiphytic species were restricted only to the base or canopy of the host plant (Appendix 1). The difference in the distribution of vascular epiphytes on a single phorophyte may depend on the surface area and exposure of the phorophyte to different environmental disturbances. In the current study area, the distribution of epiphytes was high in the trunk, medium in the canopy, and less in the basal part of the phorophyte. The point-biserial correlation between the abundance of epiphytes and basal area, trunk, and canopy was 0.153, 0.357, and 0.109, respectively. Even though they had positive correlation, their association with the abundance of epiphyte was

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insignificant at α = 0.05 (basal area; p = 0.457, r^2 = 0.023; trunk; p = 0.074, r^2 = 0.127; canopy; p = 0.597, r^2 = 0.012)

Table 3. Vertical distribution of vascular epiphytes on host zones of the phorophyte

Vertical Structure	Number of species	Cumulative percent
Basal, Trunk and Canopy	9	35
Trunk and Canopy	7	27
Basal and Canopy	6	23
Basal and Trunk	2	8
Trunk	2	8

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

Abundance of epiphytes along the Bark texture of phorophytes

The relative distribution of species on the texture of the phorophytes indicated that 63% of the epiphytes were distributed on a rough surface and 37% of the species were distributed on a smooth surface of the phorophytes. Among the 26 species identified, 9 species were specific to the rough surface of the phorophyte, 2 species were specific to the smooth surface of the phorophyte, and 15 species were not specific to the bark texture of the phorophytes (Table 4). The phorophytes with rough bark harbored a greater number of epiphyte species than the smooth barked texture (Appendix 1). The point-biserial correlation between the abundance of epiphytes and the smooth and rough bark textures of phorophytes was 0.027 and 0.263, respectively. Even though they had a positive correlation, their association with the abundance of epiphytes was insignificant at α = 0.05 (smooth texture; p = 0.895, r^2 = 0.001; rough texture; p = 0.195, r^2 = 0.0.069).

Table 4. Vascular epiphyte vs. bark textures of phorophytes

Texture of Phorophyte	No. of species	Cumulative Percent
Rough	9	35
Smooth	2	8

Abundance of epiphytes vs. DBH of phorophytes

The positive correlation (0.96) between the number of epiphytes and the size of phorophytes is significant at $\alpha = 0.05$ ($p = 0.002$). The positive correlation and the significant association show a linear relationship between the number of epiphyte species and the DBH size of the phorophytes at the mean distribution of epiphytes 11 and a standard deviation of 12.14. The Pearson correlation coefficient indicated that there was a positive and high correlation (0.92) as well as a significant association at $\alpha = 0.01$ ($p = 0.0001$) between the abundance of epiphytes and the abundance of phorophytes.

Diversity of vascular epiphytes in Farante Forest

The overall Shannon-Weiner index of the epiphytes in the study forest was 3.011 and the evenness value was 0.924. The forest has high species diversity and an even distribution of epiphyte species. *Pyrrosia schimperiana* was the richest epiphyte, with 40 individuals, followed by *Polystachya bennettiana* (37) and *Peleopeltis macrocarpa* (36).

Discussion

The number of vascular epiphyte species (26) identified from Farante Forest found at altitudes of 2000–2400 m in the Wolaita zone was very low when compared to Yayu Forest (35 species) found at 1300–1700 m altitude in Southwest Oromia (Tafa and Abuna, 2010), Doshke and Kurpaye Forest (35 species) at 2425–2550 m altitude in Gamo Gofa Zone (Getaneh and Gamo, 2006), and Gera wild coffee forest (59 species) at 1600–2400 m altitude in Jimma Zone (Bedilu et al., 2015). Even though they are mostly found in midland agroecology (1500–2500), the variation in abundance of vascular epiphytes may be due to the difference in abundance of hos plants (28) in Doshke and Kurpaye forests and Gera wild coffee forests. But the number of species of vascular epiphytes was higher than the number of vascular epiphytes containing 11 species recorded in the Gedeo agroforestry system

(Dessalegn and Tesfaye, 2018). The variation in the abundance of vascular epiphytes may be due to the number of host plants (6) and plots (32).

In the current study, the families of pteridophytes constitute the highest abundance of individuals of epiphytes, followed by orchids in the Farante Forest. It is consistent with Mojiol et al. (2009), who have reported from Kawang Forest Reserve, and Hooper and Haufler (2006), who have reported from the wet Neotropics. A similar study in Kurpaye Forest also confirmed that Polypodiaceae is the dominant family of epiphytes (Getaneh and Gamo, 2006). Also, Tesfaye (2006) from the Harenna forest in Bale, Ethiopia, has reported that the most species-rich family is Aspleniaceae (ferns), followed by Orchidaceae. This may be attributed to the presence of available microclimatic conditions for the growth of pteridophytes in the study areas.

The distribution of species of vascular epiphytes on the phorophytes is not the same from the basal parts to the topmost branches. The results of the present study revealed that the composition of species was highest in the trunk zone, followed by the canopy and basal zone, respectively. This finding was inconsistent with the study by Mohamed et al. (2017) conducted in the Wondo Genet natural forest in Ethiopia, which revealed that the species abundance of vascular epiphytes increased from base to trunk to canopy. The vertical environmental variances existing on the phorophytes clearly affect the distribution of epiphytes (Johansson, 1974; Kelly, 1985; Woods et al., 2015). Therefore, the inconsistency of this finding on the distribution of vascular epiphytes on the vertical structure of the phorophytes with the report by Mohamed et al. (2017) may be due to variations in the management of the forest or/and disturbances occurring in the zones of the phorophytes.

The epiphyte species distribution is not specific to the specific phorophytes in Farante Forest. That means a single epiphyte is grown on more than two species of phorophytes with variable occurrence. The phorophyte species having the highest abundance of epiphytes indicates the presence of favorable bark texture and fewer disturbances than the phorophyte species having the least abundance of epiphytes. Alemayehu (2010) and Dessalegn and Tesfaye (2018) similarly reported that most vascular epiphytes were not host-specific and had variable frequency (Benzing, 1990). Munoz et al. (2004) reported the significant preferences of epiphytes for one or two host tree species. The occurrence of different epiphyte species on different phorophytes, for example, is related to the phorophyte morphology and its age (Bittner and Trejos, 1997).

The Phorophytes with rough bark harbored more epiphyte species than those smooth-barked textures. This may be due to the provision of suitable habitat by the rough bark of phorophytes for the growth of the epiphytes than smooth bark. Similar finding by Hietz (1999) confirmed that trees with a rough bark help the establishment and germination of epiphytes seed. Thus, Munoz (2004) also confirmed that the smoother texture of host bark could harbor a lower epiphytic cover compared with the rough textures of tree species in the forest. The observation on bark texture confirmed that barks with a rough texture have diverse and more abundant epiphytes due to their high water content and water retention capacity (Bayisa Abdisa, 2019).

The findings of the current study revealed that there was a positive correlation between the number of epiphytes and the DBH size of the phorophytes, as well as between the abundance of epiphytes and the abundance of phorophytes. This indicates that the phorophytes having a large-sized DBH can harbor more epiphytes than the less-sized phorophytes, and the increasing abundance of phorophytes in turn also increases the number of epiphytes. The study carried out on the diversity and ecology of vascular epiphytes in the Harenna Afromontane forest similarly confirmed that the correlation test showed that the number of species of vascular epiphytes and the size of the host tree are positively correlated (Alemayehu, 2006). The positive correlation and the significant association show the linear relationship between the number of epiphyte species and the DBH size of the phorophytes at the computed mean distribution of epiphytes and standard deviation. There was the highest correlation between the trunk of phorophytes and the abundance of epiphytes, but the correlation between smooth bark and abundance was the least. The highest positive correlation between the abundance of epiphyte and phorophyte trunks and the least positive correlation between the abundance of epiphyte and phorophytes' smooth bark texture indicated a change in the phorophyte zone and bark texture due to the disturbance. Liu and Xu (2005) also similarly reported a significant positive relationship and association between trunk size and epiphyte abundance. The finding indicates that the thickness of phorophytes has brought more opportunity for accumulating spores and preparing a habitat for epiphytes. Besides, the DBH and bark texture of phorophytes have an efficient influence on the composition of vascular epiphytes in a given forest. This is consistent with the fact that the change in species composition of vascular epiphytes is associated with changes in forest disturbance, the vertical gradient of microclimate on the single host plant, DBH and bark texture of phorophytes, and elevation (Dessalegn and Tesfaye, 2018).

Acknowledgments

We would like to express our sincere gratitude to Wolaita Sodo University for its financial support in this research project.

Funding

This work has been funded by Wolaita Sodo University.

Data availability

Data are obtained upon request to the corresponding author.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions

The co-author has contributed to the data collection, reading, and approval of the final article. The corresponding author has specifically contributed to the data analysis and write-up of the manuscript.

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Journal of Science and Inclusive Development Vol. 5, No. 2, DOI:10.20372/jsid/2023-252

Appendices

Appendix 1. Distribution of species on vertical zones and Bark texture of phorophytes

Species	Family	Vertical Structure			Bark Texture	
		Basal	Truck	Canopy	Sooth	Rough
Achyrospermum schimperi (Hochst.exBriq.) Perkins	Lamiaceae	+	+	+	+	
Asplenium aethiopicum (Burmf) Bech.	Aspleniaceae	+	+	+	+	+
Asplenium cf. bugoiense Hieron.	Aspleniaceae	-	+	+	+	+
Asplenium smedsii Pic. Serm.	Aspleniaceae	+	+	+	+	+
Asplenium theciferum (Kunth.) Mett.	Aspleniaceae	+	+	+	+	+
Autilon sp.	Malvaceae	+	-			+
Bidens pilosa L.	Asteraceae	+	+	+	+	+
Bolusiella iridifolia (Rolfe) Schltr.	Orchidiaceae	-	+	+	+	+
Crassocephalurn rubens (Juss. ex Jacq.) S. Moore	Asteraceae	-	+	+		+
Cyrtorchis arcuata(Lindl.) Schltr.	Orchidiaceae	-	+	+	+	+
Drynaria volkensii Hieron.	Polypodiaceae	+	-	+	+	+
Ficus thonningii Blume	Moraceae	+	-	+	+	
Galinsoga parviflora Cav.	Asteraceae	-	+	+	+	+
Hypoestes forskaolii (Vahl) R. Br.	Acanthaceae	-	+	+		+
Lepisorus excavatus (Willd) Ching	Polypodiaceae	+	-	+	+	+
Loxogramme lanceolata (SW) Pers	Polypodiaceae	+	+	+	+	+
Peleopeltis macrocarpa (Bory ex Willd.) Kaulf.	Polypodiaceae	+	-	+	+	+
Phaulopsis imbricata (Forssk.) Sweet	Acanthaceae	-	+	-		+
Phyllanthus sp.	Euphorbiaceae	-	+	-		+
Plectranthus alpinus (Vatke) Ryding	Lamiaceae	+	-	+		+
Plectranthus sp.	Lamiaceae	+	+	+		+
Polystachya bennettiana Rchb.f.	Orchidiaceae	+	+	+		+
Pteridium aquilinum (L.) Kuhn	Hypolepdiaceae	+	+	+		+
Pyrrosia schimperiana (Mett.ex Kuhn.) Alston.	Polypodiaceae	+	+	-		+
*Salvia nilotica*Jacq.	Lamiaceae	-	+	+		+
Tridactyle bicaudata (Lindl.) Schltr.	Orchidiaceae	+	+	+	+	+

Appendix 2. Abundance of epiphyte and phorophytes

Epiphytes name	Abundance of epiphytes	Phorophytes name	Abundance of Phorophytes
Galinsoga parviflora Cav.	3	*Acacia abyssinica* Hochst.e.	14
Salvia nilotica Jacq.	6	*Ficus vasta* Forssk.	14
Ficus thonningii Blume	12	*Olea europaea* subsp. *cuspidate* L.	14
Plectranthus sp.	7	*Croton macrostachyus* Del.	13
Phyllanthus sp.	8	*Ficus sur* Forssk.	12
Pteridium aquilinum (L.) Kuhn	5	*Cordia africana* Lam.	12
Asplenium aethiopicum (Burmf) Bech.	25	*Buddleja polystachya* Fresen	12
Drynaria volkensii Hieron.	32	*Acacia seyal* Del.	11
Autilon sp.	4	*Erythrina brucei* Schweinf.	10
Asplenium cf. bugoiense Hieron.	23	*Podocarpus falcatus* (Thunb.)	9
Crassocephalurn rubens (Juss. ex Jacq.) S. M	6	*Maytenus serrata* (A.Rich.)Wilczek	8
Bidens pilosa L.	10	*Millettia ferruginx* Benthea (Hochst.)	7
Loxogramme lanceolata (SW) Pers	34	*Syzygium guineense* (Willd.) DC	7
Plectranthus alpinus (Vatke) Ryding	8	*Dovyilas abssynica*	7
Achyrospermum schimperi (Hochst.exBriq.)	11	*Rhus glutinosa*	6
Phaulopsis imbricata (Forssk.) Sweet	1	*Carissa edulis* (Forssk.)	5
Tridactylebi caudata (Lindl.) Schltr.	28	*Schrebera alata* (Hochst.)	4
Hypoestes forskaolii(Vahl) R. Br.	7	*Combretum molle* R. Br. ex G.Don	4
Lepisorus excavatus(Willd) Ching	27	*Celtis africana* Burm.f.	4
Asplenium theciferum(Kunth.) Mett.	24	*Ficus ovata* L.	3
Peleopeltis macrocarpa (Bory ex Willd.) Kau	36	*Terminalia schimperiana* Hohst	3
Pyrrosia schimperiana (Mett.ex Kuhn.) Alst	40	*Juniperus procera* Hochst.exEngl	3
Cyrtorchis arcuata (Lindl.) Schltr.	23	*Hagenia abyssinica* (Bruce) J.F.Gmel	3
Polystachya bennettiana Rchb.f.	30	*Ehretia cymosa*Thonn.	1
Asplenium smedsii Pic. Serm.	24	*Vernonia amygdalina* Del.	1
Polystachya bennettiana Rchb.f.	37		