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Epiphyte Diversity on Avenue Trees of National and State Highways of Udupi District, Karnataka, India

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Abstract

The epiphytic diversity on avenue trees was assessed in one national highway and two state highways of Udupi district, Karnataka. The study showed that diversity of epiphytes on woody substratum comparatively similar in two state highways and one national highway of the study area, but recorded high abundance of epiphytes on fast growing, exotic tree varieties in national highways as compared to the state highways. There is no significant difference between Shannon's diversity and Pielou's evenness values between National Highway 66 (2.183, 0.878) and State Highways (2.304, 0.927). The abundance of encountered epiphytic species belongs to Family Orchidaceae. The native avenue trees with larger girth supported more epiphyte species in both the national and state highways.

Keywords: Epiphyte, highways, diversity.

Introduction

Vascular epiphytes in tropical rain forests are a hyper diverse group. Although they are often overlooked because of their isolation in the treetops, their contribution to the lowland rain forest vascular flora is significant, with estimates of 10% of the total vascular flora[1,2]. Epiphytes are food sources and habitat for a variety of insects, birds and other organisms[3]. Epiphytes are used extensively by man for medical, agricultural and horticultural purposes. It has been used as bioindicators of climatic changes, pollution, and ecological damage[4]. Epiphytes are responsible for much of the biotic diversity that makes humid tropical forests the most complex of all the world's terrestrial ecosystems[5]. The shrub layer epiphytes are normally dependant on large mature trees that have upon them an abundant epiphyte community[6]. Epiphyte forms a major component of the diversity of tropical forests[7]. Vascular epiphytes were helpful in water balance and nutrient cycling[8]. Epiphytes are distributed horizontally and vertically. The crowns are much richer than the trunk in epiphytic species. Most of herbaceous vascular epiphytes are lacking from the tropics due to habitat destruction[9]. Epiphytes are extremely important elements of the flora (they represent about 10% of all plant species globally)[10]. Vascular epiphytes, including orchids, bromeliads, aroids, ferns, among others, are key components of species richness[11]. The presence of individual species, including crustose lichens and bryophytes, in seven habitats representing different canopy positions, based on a sample of twenty trees in an old conifer forest. Many authors have contrasted epiphytes on various species of trees. The studies demonstrated some important patterns of variation in epiphytes. These are i. quantification of the relative strength of these various patterns, ii. consideration of dead trees as habitat for epiphytes and iii. synthesis and reconciliation of seemingly separate results from various regions[12]. The vertical distribution of epiphytes is mostly determined by patterns in photon flux density (PFD) and humidity in subsequent forest strata. The specific humidity level is also an important factor for diversity and composition of epiphyte[13]. The diversity of epiphytic flora may provide an indication of ecosystem health as they are considered as an important component of plant life which constitutes about 10% of world flora. The epiphytic diversity and its abundance depend on the forest structure, tree species composition and atmospheric humidity. Tree species composition affects epiphytic vegetation through substratum characteristics provided by each supporting tree species, giving rise to host-epiphyte specificity[14]. There are in fact up to 25000 species of vascular epiphytes alone that occur mainly in tropics[15]. The epiphytes are important with relation to the biological diversity maintaining a balance in nature. Due to anthropogenic activities, pollution is on all the time rises and therefore epiphytes are found declining in number. Due to the shrinkage of forest areas and need for timber and firewood, the avenue trees are also being destroyed day by day, cheating epiphytes of their natural habitat. In the present work an assessment of diversity of epiphytes on avenue trees of the study area has been done.

Study Area: The present study is carried out in one National Highway (NH 66) and two State Highways (SH) namely Udupi to Karkala and Kundapura to Siddapura (table-1), 13°06' 20.86''N to 13°12.52''N and 74°47' 13.12'' to 74°37' 43.31''E. (figure-1). The National Highway (NH 66) is in close proximity to the coastal belt of Karnataka. The Two State Highways (SH) namely Udupi to Karkala and Kundapura to Siddapura the proximity is the rich vegetation of the forest because the study area is nearer to Kudremukh National Park and Kollur Mookambika reserve forest rather than the coastal belt.

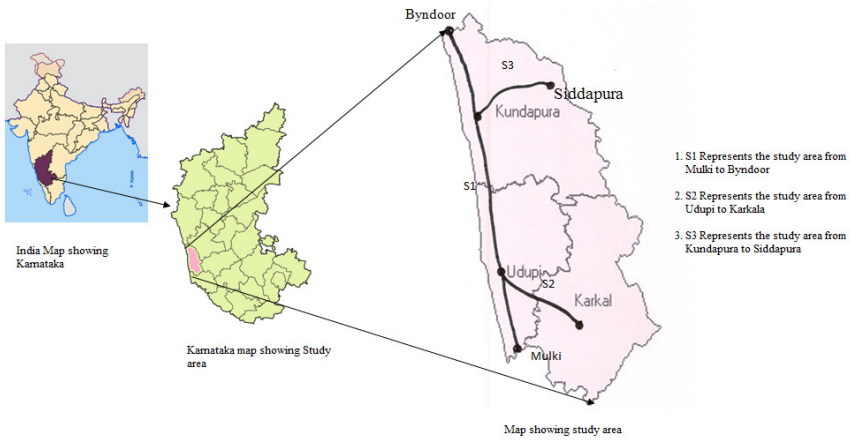

Figure-1
Map of study area

The study area was represented in table 1.

Table-1
Study area

Study area		Site no.
National Highway (NH66)	Mulki to Byndoor	S1
State Highway (SH)	Udupi to Karkala	S2
State Highway (SH)	Kundapura to Siddapura	S3

Material and Methods

50x20 m Belt transacts was used for the epiphytic sampling. Transacts were laid randomly just next to the footpath on either sides. 90 and 60 transacts were laid in NH and SH respectively. Girth at breast height (GBH) ≥ 30cm and the height of all trees in transact was recorded. Their occurrence and height were noted. The epiphytes present in transacts were identified using standard key books. Dried specimens are then mounted on herbarium sheets of standard size 29x42 cm using synthetic glue and the woody part of the specimen is stitched using white coloured thread. The specimens like patches of mosses and the orchids are preserved in 70% alcohol.

Shannon-Wiener's diversity was used to calculate the variation in epiphytic species diversity of the study area along the national and state highways using the formula:

$$H' = {}^{s}\sum_{i} Pi \log_e (Pi)$$

Where *s is* the number of species, and P*i* is the proportion of the total number of individuals consisting of the i^{th} species.

Results and Discussion

The avenue trees found in the study area are represented in the table-2. The table-2 reveals more number of avenue trees are found in state highways than in the National Highway 66 (N.H.66). The epiphytes present on the avenue trees are represented in table-3.

Table-2
Avenue trees found in the study area

Botanical name of the avenue tree	S1	S2	S3
Acacia auriculiformis	+	+	+
Acacia sinuate	+	+	+
Albizia lebbeck	+	+	+
Alstonia scholaris	+	+	+
Artocarpus heterophyllus	+	+	+
Artocarpus hirsutus	+	+	+
Borassus flabellifer	-	+	+
Casuarina equisetifolia	+	+	+
Calophyllum inophyllum	-	+	+
Caryota urens	-	+	+
Dalbergia sissoides	-	+	+
Erythrina variegata	+	+	+
Eucalyptus tereticornis	+	+	+
Ficus benghalensis	+	+	+
Ficus religiosa	+	+	+
Hopea parviflora	+	+	+
Hopea ponga	-	+	+
Mammea suriga	-	+	+
Mangifera indica	+	+	+
Mimusops elengi	+	+	+
Morinda citrifolia	-	+	+
Olea dioica	-	-	+
Pongamia pinnata	-	+	+
Pterocarpus marsupium	-	+	+
Samanea saman	+	+	+
Syzygium cumini	-	+	+
Tectona grandis	-	+	+
Vatica chinensis	-	+	+
Vateria indica	+	+	+

From the current study it is observed that *Acacia auriculiformis, Artocarpus heterophyllus, Casuarina equisetifolia, Eucalyptus tereticornis, Samanea saman, Mangifera indica,* and *Tectona grandis* are more common. The epiphytes and the parasites are absent on *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus tereticornis* and *Vateria indica*. The epiphytes are commonly found on *Artocarpus heterophyllus, Artocarpus*

hirsutus, Dalbergia sissoides, Ficus religiosa, Ficus benghalensis, *Mammea suriga, Mangifera indica, Pongamia pinnata, Samanea saman.*

The epiphytes which are common in the Udupi district are *Calymperes tenerum* (Calymperaceae), *Sematophyllum caespitosum* (Sematophyllaceae), *Taxithelium nepalense* (Sematophyllaceae), *Drynaria quercifolia* (Polypodiaceae), *Acampe praemosa*, *Bulbophyllum neilgherrence, Cleisostoma tenuifolium, Dendrobium ovatum, Rhynchostylis retusa, Vanda testacea* (Orchidaceae) (table-3). There is no significant difference between Shannon's diversity and Pielou's evenness values between National Highway N.H. 66 (S1) is (2.183, 0.878) and state highways (S2 and S3) is (2.304, 0.927). But on comparison between the two values State Highway has more diversity than the National Highway.

The distribution of epiphytes in National and state highways are represented in table-4.

Table-3
The epiphytes present on the avenue trees of study area

S. No.	Name of the plant	Type of the plant	Family
1	*Calymperes tenerum* C. Muell.	Bryophyte	Calymperaceae
2	*Sematophyllum caespitosum* (Hedw.) Mitt.	Bryophyte	Sematophyllaceae
3	*Taxithelium nepalense* (Schwaerg.) Broth.	Bryophyte	Sematophyllaceae
4	*Drynaria quercifolia* (L.)J.Sm.	Pteridophyte	Polypodiaceae
5	*Acampe praemosa* (Roxb.) Blatt. & McCann.	An orchid	Orchidaceae
6	*Bulbophyllum neilgherrense* Wight.	An orchid	Orchidaceae
7	*Cleisostoma tenuifolium* (L.) Garay	An orchid	Orchidaceae
8	*Dendrobium ovatum*(Willd.)	An orchid	Orchidaceae
9	*Rhynchostylis retusa* Blume	An orchid	Orchidaceae
10	*Vanda testacea*(Lindl.)Reichb.	An orchid	Orchidaceae

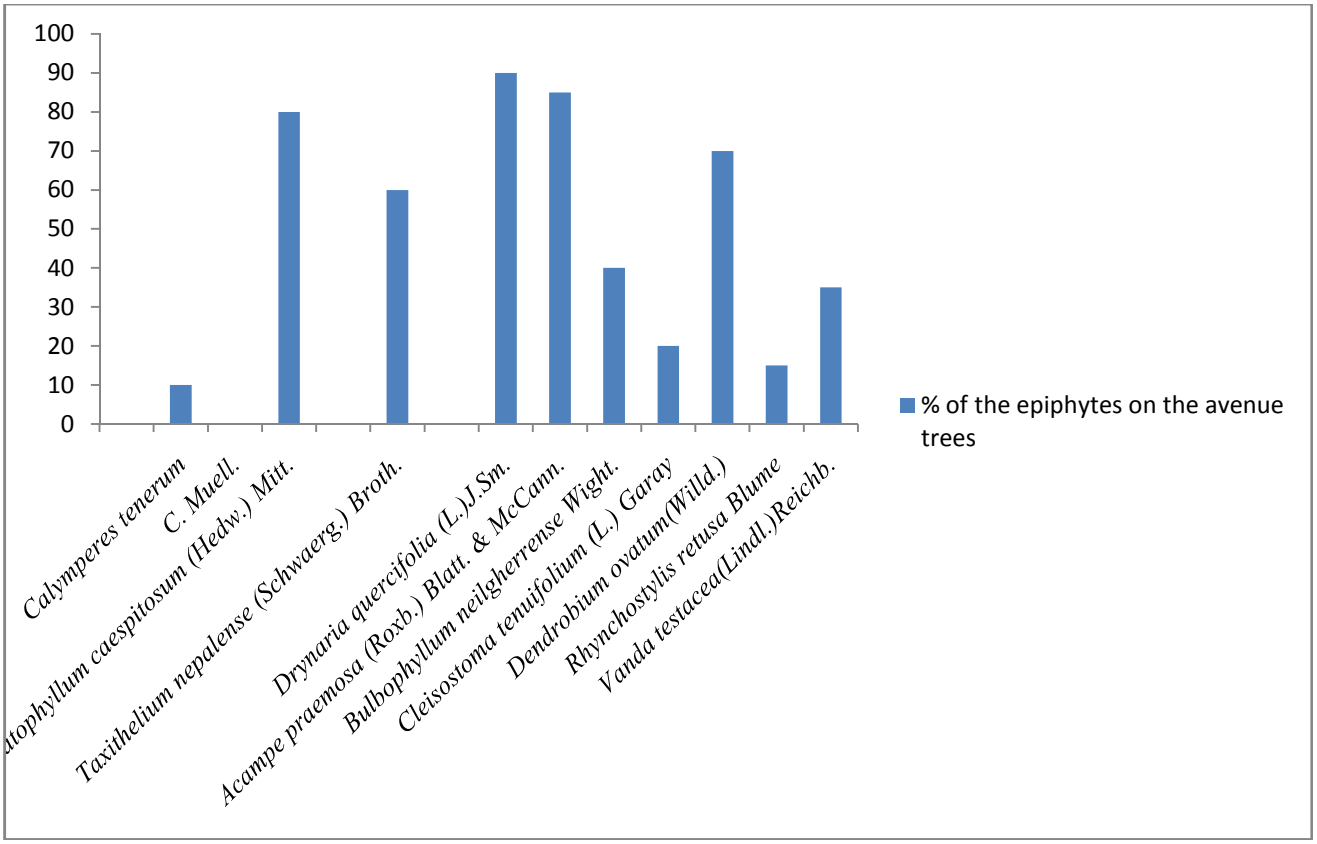

Figure-2
Distribution of epiphytes along the study area S2 and S3

Table-4
The distribution of epiphytes in National and state highways

Avenue tree species	***Cal***	***Sem***	***Tax***	***Dry***	***Aca***	***Bul***	***Cle***	***Den***	***Rhy***	***Van***
Acacia auriculiformis	-	-	-	-	-	-	-	-	-	-
Acacia sinuate	-	-	-	-	-	-	-	-	-	-
Albizia lebbeck	+	+	+	+	-	-	-	-	-	-
Alstonia scholaris	-	-	-	-	-	-	-	-	-	-
Artocarpus heterophyllus	+	+	+	+	+	+	+	+	+	+
Artocarpus hirsutus	+	+	+	+	+	+	+	+	+	+
Borassus flabellifer	+	+	+	+	-	-	-	-	-	-
Calophyllum inophyllum	-	-	-	-	-	-	-	-	-	-
Caryota urens	-	-	-	+	-	-	-	-	-	-
Casuarina equisetifolia	-	-	-	-	-	-	-	-	-	-
Dalbergia sissoides	+	+	+	+	+	-	-	-	-	+
Erythrina variegata	+	+	+	+	+	-	-	-	-	-
Eucalyptus tereticornis	-	-	-	-	-	-	-	-	-	-
Ficus benghalensis	+	+	+	+	+	-	-	-	-	+
Ficus religiosa	+	+	+	+	+	-	-	-	-	+
Hopea parviflora	+	-	+	-	-	-	-	-	-	-
Hopea ponga	+	+	+	-	+	+	-	-	-	-
Mammea suriga	+	+	+	+	+	+	+	+	+	+
Mangifera indica	+	+	+	+	+	+	+	+	+	+
Mimusops elengi	+	+	+	+	+	-	-	-	-	-
Morinda citrifolia	-	-	-	-	-	-	-	-	-	-
Olea dioica	+	+	+	+	+	+	-	-	-	-
Pongamia pinnata	+	+	+	+	+	+	+	+	+	+
Pterocarpus marsupium	+	+	+	+	+	-	-	-	-	-
Samanea saman	+	+	+	+	+	-	-	-	-	-
Syzygium cumini	+	+	+	+	+	-	-	-	-	-
Tectona grandis	-	-	-	+	-	-	-	-	-	-
Vateria indica	-	-	-	-	-	-	-	-	-	-
Vatica chinensis	-	-	-	-	-	-	-	-	-	-

Cal – *Calymperes tenerum* C. Muell., ***Sem*** – *Sematophyllum caespitosum* (Hedw.) Mitt. ***Tax*** – *Taxithelium nepalense* (Schwaerg.) Broth., ***Dry*** – *Drynaria quercifolia* (L.)J.Sm., ***Aca*** – *Acampe praemosa* (Roxb.) Blatt. & Mc Cann., ***Bul*** – *Bulbophyllum neilgherrense* Wight., ***Cle*** – *Cleisostoma tenuifolium* (L.) Garay., ***Den*** – *Dendrobium ovatum* (Willd.)., ***Rhy*** – *Rhynchostylis retusa* Blume., ***Van*** – *Vanda testacea* (Lindl.) Reichb.

Herbaceous vascular epiphyte species are less in number and are within the range of six in study area. Since the study area receives only moderate to heavy rainfall with a dry period of 4–5 months per year, epiphyte diversity is found to be less. Epiphytes mostly occurred on trees located along the State Highways S2 and S3 (figure 2 and 6), than the National Highway S1 (figure 3 and 6).

According to Benzing[1], the high canopy dwellers must be able to withstand frequent periodic droughts. All the orchid species among them are small-sized and succulent and some of them have terete leaves. The water-absorbing capacity of the trichomes of *Tillandsia* has been demonstrated. In the present study, it has been also observed in Udupi district. The epiphytes mainly the orchids show various modifications like the presence of thick elongated roots along with the velamen tissue, presence of pseudobulbils, and thick succulent leaves which help the plants to absorb moisture from the environment and conserve water. In *Drynaria quercifolia* the presence of pocket leaves is an additional feature which also helps in the collection of organic matter and debris. Atmospheric moisture seems to be the most important ecoclimatic variable[2] mainly to the cryptogamic types i.e. three genera from bryophytes and one genus from pteridophyta. Six epiphytic genera from angiosperms belong to family Orchidaceae are reported.

According to Sanford[13], distibution of hemiparasites and hemiepiphytes can vary in at least two ways: horizontally, they can differentiate between host species and forest types, and vertically where they vary from the tree base to its top. The following substratum factors are relevant: texture (roughness) and porosity of bark (water interception and storage, grip for diaspores); pH and nutrient contents of bark, cover and characteristics of litter and bryophyte mats, bark toxins and bark turn-over rate. The vertical distribution of epiphytes is mostly determined by patterns in photon flux density (PFD) and

humidity in subsequent forest strata. For instance, many epiphytic Bromeliaceae members show specific humidity demands. In present study, it has been found that, in Udupi district distribution of the epiphytes and parasites varies in the given study area. On the National Highway the number of epiphytes is less compared to the State Highways and the moss mats are common on the State Highways on the avenue trees. On the National Highway, N.H.66 *Acacia auriculiformis, Artocarpus heterophyllus, Casuarina equisetifolia, Eucalyptus tereticornis, Samanea saman, Mangifera indica,* and *Tectona grandis* are more common. The epiphytes are commonly found on *Artocarpus heterophyllus, Artocarpus hirsutus, Ficus religiosa, Ficus benghalensis*, *Mangifera indica,* and *Samanea saman*. The epiphytes are absent on *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus tereticornis* and *Vateria indica* (table - 4), where the bark is thin or absent because of peeling. On the State Highway *Samanea saman, Artocarpus heterophyllus, Tectona grandis* and *Mangifera indica* are more common. The epiphytes are commonly found on *Artocarpus heterophyllus, Artocarpus hirsutus, Dalbergia sissoides, Elaeocarpus tuberculatus, Ficus religiosa, Ficus benghalensis*, *Mammea suriga, Mangifera indica, Pongamia pinnata, Samanea saman* and *Tectona grandis.* On the State Highway, most of the trees have thick bark. This stores water and organic matter. The National Highway N.H.66 is in proximity to the Arabian Sea with increasing humidity but rain fall is comparatively less because of deforestration. In the areas of State Highway, there are wild life conservation parks like Kudremukh National Park near to Udupi – Karkala State Highway and Mookambika Reserve Forest near to Kundapura – Siddapura State Highway which have rich ever green vegetation, thereby increasing the moisture and organic matter. Hence epiphytes are more common in State Highways.

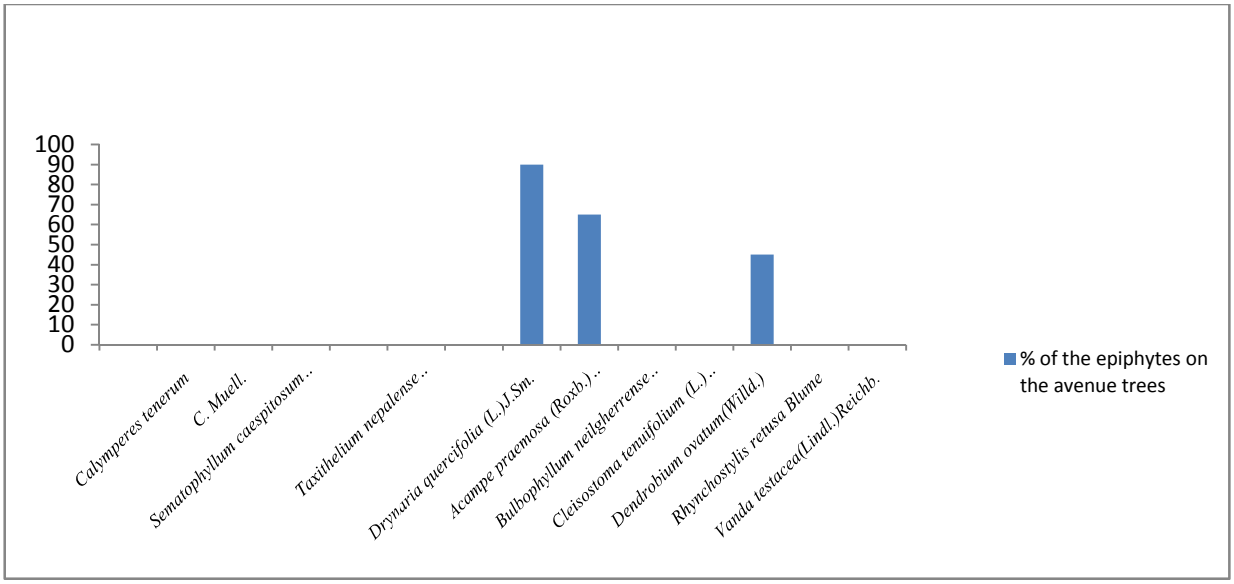

Figure-3
Distribution of epiphytes along the study area S1

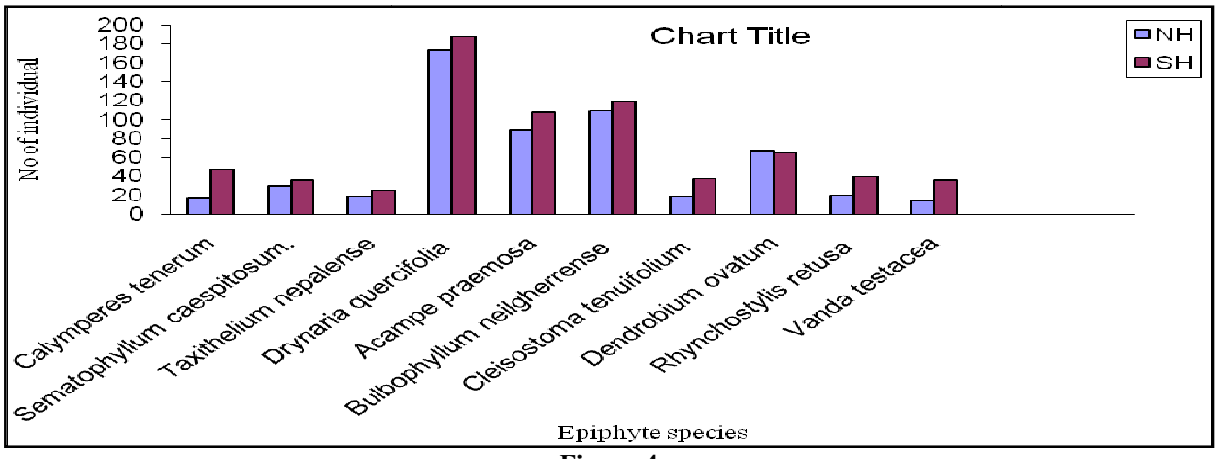

Figure-4
Distribution of epiphytes along the study area S1, S2 and S3

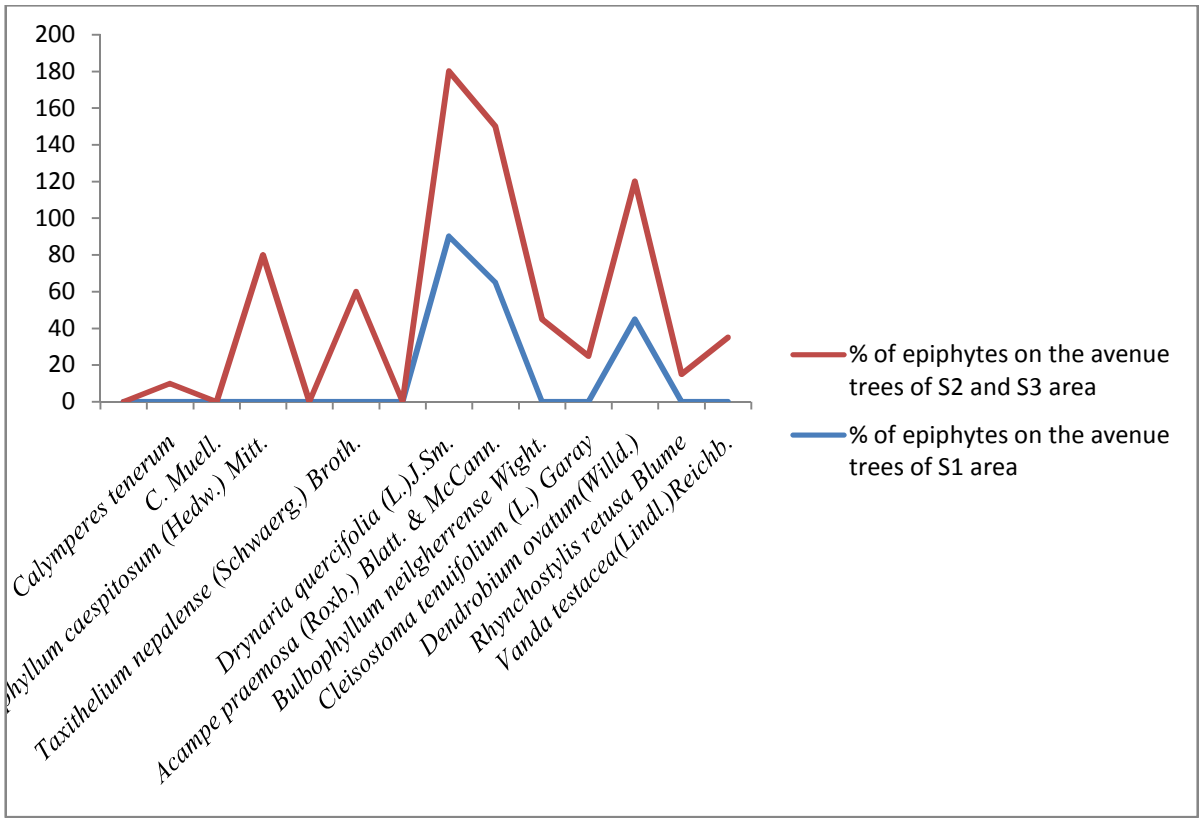

Figure-5
Distribution of epiphytes along the study area S1, S2 and S3

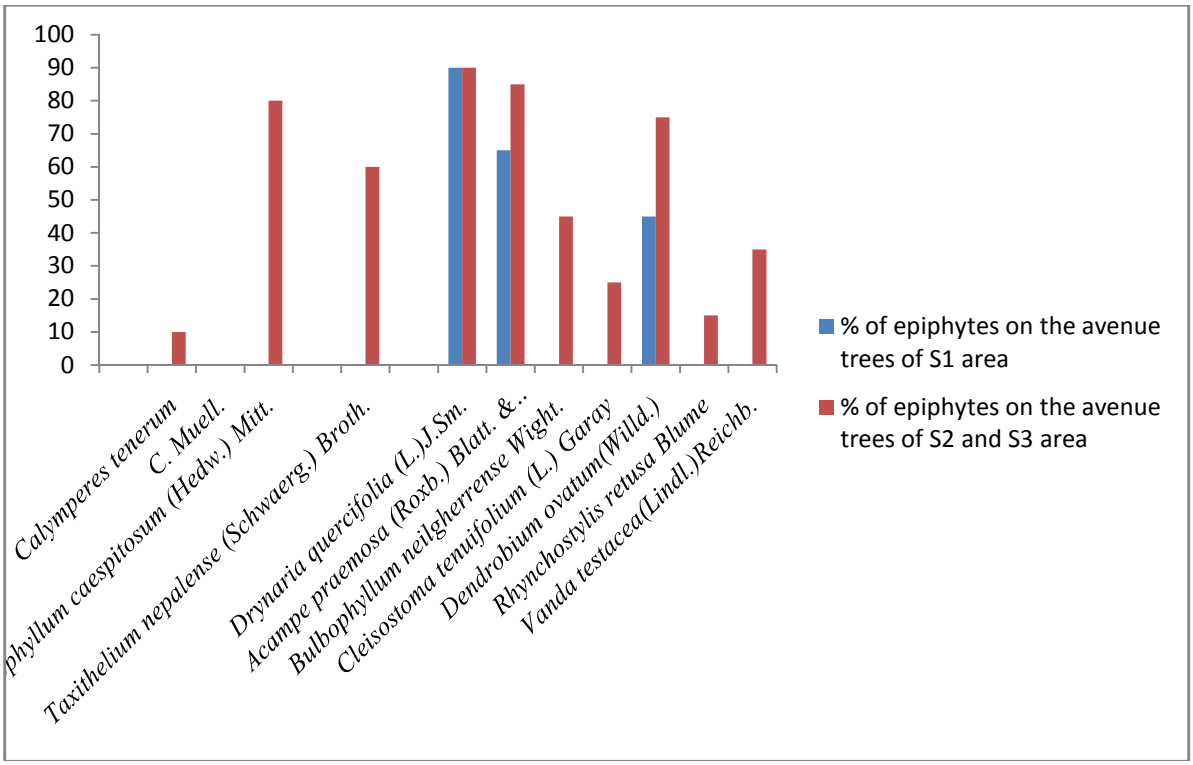

Figure-6
Percentage of distribution of epiphytes along the study area S1, S2 and S3

Figure-7
***Calymperes tenerum* - On tree surface**

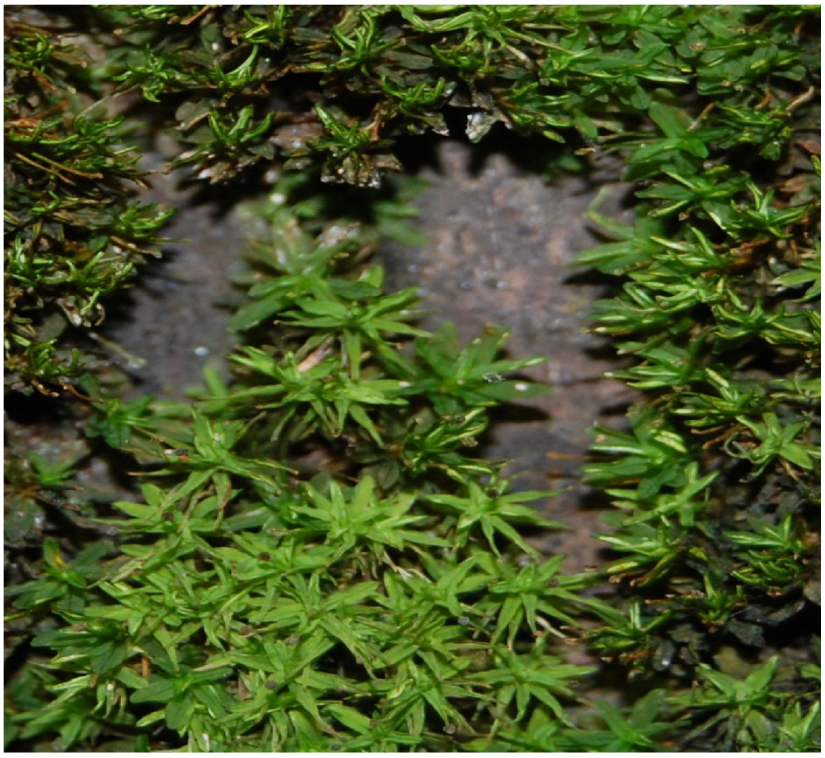

Figure-8
***Sematophyllum caespitosum* - On tree surface**

Figure-9
***Drynaria quercifolia* - On tree surface.**

According to Went[14], the different epiphyte vegetations may be found in different lowland rain forest types. This is related to forest structure, tree species composition, and atmospheric humidity. Tree species composition affects epiphytic vegetation through substratum characteristics provided by each tree species, giving rise to host-epiphyte specificity. But in Udupi district, the epiphytes which are present on the avenue trees do not show host specificity but it has been observed that *Mangifera indica* and *Samanea saman* supports more number of epiphytes probably because in these plants the presence of very thick bark helps in the accumulation of moisture and organic matter. Limited epiphytes were observed on the plants like *Dalbergia sissoides, Elaeocarpus tuberculatus, Mammea suriga* and *Pongamia pinnata* probably because of their thin bark which is unable to support organic matter and moisture. The epiphytes were totally absent in *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus tereticornis* and *Vateria indica* because in these peeling of bark reduces the moisture and organic matter to almost nil (table - 4).

In the present study, it is observed that *Drynaria quercifolia* is more common and present on most of the avenue trees of the study area. The present study also indicates that *Acampe praemosa* was more commonly present on *Mangifera indica*. The rest of the orchids are present on most of the avenue trees.

Among the mosses *Sematophyllum caespitosum* was more common. The three types of the mosses (*Calymperes tenerum, Sematophyllum caespitosum* and *Taxithelium nepalense*) were more commonly present on *Mangifera indica* and *Samanea saman.*

Epiphytes grow very well on old avenue trees. In most of the young trees the epiphytes were absent. As the plant becomes older the number of epiphytes and parasites increases. In young trees only one type of moss was found where as in older avenue trees all the three types of mosses reported in the present study were found. When the tree grows older and becomes woody the variety of epiphytes goes on increasing.

Conclusion

The epiphytes are absent on *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus tereticornis* and *Vateria indica*. The epiphytes are commonly found on *Artocarpus heterophyllus, Artocarpus hirsutus, Dalbergia sissoides, Elaeocarpus tuberculatus, Ficus religiosa, Ficus benghalensis*, *Mammea suriga, Mangifera indica, Pongamia pinnata, Samanea saman* and *Tectona grandis.* In most of the avenue trees, mosses and *Dynaria quercifolia* are more common and occur in large number. The epiphytes which are common in Udupi district are *Calymperes tenerum* (Calymperaceae), *Sematophyllum caespitosum* (Sematophyllaceae), *Taxithelium nepalense* (Sematophyllaceae), *Drynaria quercifolia* (Polypodiaceae), *Acampe praemosa*, *Bulbophyllum neilgherrence, Cleisostoma tenuifolium, Dendrobium ovatum, Rhynchostylis retusa, Vanda testacea* (Orchidaceae) (table - 3).

There is no significant difference between Shannon's diversity and Pielou's evenness values between National Highway (N.H.66) the study area S1 (2.183, 0.878) and State Highways the study area S2 and S3 (2.304, 0.927). It shows more epiphytic diversity on the avenue trees of State Highway than on the avenue trees of National Highway. Pielou's evenness value shows that the distributions of epiphytes were more or less same.

On the National Highway, due to dust, pollution, heavy traffic and lesser amount of rain fall, the epiphytes were found fewer in number and variety. Many epiphytes were found on older trees having thicker bark containing more organic material and moisture. Younger trees did not support much epiphytes growth.

On the State Highway, owing to less traffic and heavier rain fall, the varieties of epiphytes were much greater than on the National Highways.

In National Highway (N.H.66), (S1) lots of trees were being cut for the purpose of broadening of the road in order to allow more traffic. Because of this, epiphytes have lost their natural habitat and in the process some rare epiphytes belonging to the family Orchidaceae are on the verge of extinction. Afforestration is taking place on a large scale but the trees used for afforestration are *Acacia auriculiformis, Casuarina equisetifolia*, *Eucalyptus tereticornis,Vateria indica* etc. These trees are fast growing but have a very thin or no bark due to peeling probably they cannot support epiphytes, thus leading to a reduction in their number.

On the State Highways S1 and S2, (Udupi to Karkala and Kundapura to Siddapura) however avenue trees are naturally growing and have epiphyte supporting characteristics. Hence here the growth of epiphytes was found much more than on the avenue trees of National Highway. But due to lack of awareness, the avenue trees are also being cut for different uses. Hence these avenue trees show the risk factor for the survival of the epiphytes on them.

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