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Research Article

Phorophyte specificity of lichen community, with ecological taxation in Suruli watershed, Southern Western Ghats

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ABSTRACT

The Lichens is an essential component of all kinds of ecosystems. They are one of the flora's dominant components, and it accumulates about eight percent of the terrestrial ecosystem. India is an assorted vegetative tropical country. Four major ecological factors produce several microclimatic niches for the growth of lichens in the Western Ghats. First attempt to correlate the lichen population and species richness with the natural and silviculture challenges. During collection, surprisingly uninformed rainfall has observed in the summer season too. Eco-lichenological ranks premeditatedly founded on altitude, geo-specificities, substrates or habitats and morpho-types. The environmental variables revealed that the lichen density was more about spring to summer (27.3 to 25.5%), 23.5 to 18.5% during the winter and late autumn periods. The luxuriant growth of lichen thalli has notified on the rainy and Autumn seasons. Meanwhile, the crustose group of fruiting bodies flourished during the summer season. The terrestrial forest habits occurring on the cryptogamic and phanerogamic plants, including lichens. Most forests hold with the tribal and ethnic community; they suffered from terrestrial human and motor vehicle movements and forest fires, landslides, and more, including endangered species. Natural and manmade forestation practises to be regulating to conserve forest and dependences.

Key words: Climate, Diversity, Lichen, Suruli waterfalls, South Western Ghats.

INTRODUCTION

Cryptogams are very popular green micro mates of the earth. Bryophytes and fungal apparatuses play significant roles in forests, such as oxygen traducement and natural decomposing agents. The Lichens is an essential component of all kinds of ecosystems (Burbanck & Platt, 1964). The mixture of myco (fungal) with phyco (algal), with or without viral and bacteriological (purple and blue-green alga) components were living in one host as symbiont(s) (Gerson & Seaward, 1977; Petrzik *et al*., 2019). It is the significantly earlier well-known myco-biotic beneficial organism. It covers almost 12 percentage of the terrestrial and forest ecosystem. Based on morpho and chemotaxonomic nature and modern phylogenetic techniques, classified it. The world record is nearly 20,000 species from six groups (crustose, foliose, fruticose, fibrils, leprose and squamulose) in two major fungal (Asco and Basidiomycetes) groups. The representation of various growth forms, including shapes, size, and colour, is abundant in tropical forests compared to other forest types. Foliose and fruticose gradually increase their growth on the absorption of nutrients from the host and atmospheric NO_2 (Awasthi, 1991). Crustose growth forms are a very slow-growing organism of the whole lichen community because of their peculiar non-plant-derived chemical compositions (secondary metabolites) in the medulla and cortex of the thalli (Vertika Shukla *et al*., 2013). India is a diverse region for multiple floral and faunal variation with harmonious lichen diversity. The thallophyte ranges accumulated in eight different licheno-geographical regions in India provide the vast distribution and dense occurrence. Still, it reported with 2543 species from 305 genera and 75 families. (Singh *et al*., 2019; Rajaprabu *et al*., 2021). Seven hundred thirty-seven lichen taxa described in western ghats holding 1096 (with ~16 intraspecific species), in Tamil Nadu state from only the Western Ghats. (Sanjeeva Nayaka & Dalip Kumar Upreti, 2011). The second most majority of lichen communities recorded from the Western Ghats of Tamil Nadu in India (Zachariah *et al*., 2020). The battle between plants and other organisms, in general, for water, light, and nutrition. However, these lichens are gathering atmospheric nitrogen, too (Upreti and Chatterjee, 1999).

India is an assorted vegetative tropical country. However, it occupies 35% of dry and 46% deciduous forests and 19% of seashore beaches and savannas documented, both in Eastern Ghats (E.G.s) and Western Ghats (Kaul *et al.*, 1991). Western Ghats (W.G.s) of India covering chains of hills around 1500 kilometre of land area. Under the favourable environmental and elevation gradients, different vegetation types monitored. Such as evergreen, semi-evergreen, dry and moist

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deciduous forests exist in the Western Ghats. The second most extensive number of lichens diversity has revealed from this Southern west conjoined part of the Indian subcontinent, Pronounced, almost five states (Goa, Maharashtra, Karnataka, Kerala and Tamil Nadu) and four agroclimatic geographical zones have divided from here. This biodiversity hotspot has separated into four sites identically, the Northern WGs, Central WGs, Nilgiris and Southern Western Ghats based on the regional geographical classification. There is a drastic reduction in species density, abundance and richness due to excess rainfall, fragmentation, natural and anthropogenic effects, silviculture practices and global environmental changes.

Consequently, the lichens have been influencing the forest structure and compositions. There is a need to resemble the most important for enlightening species richness patterns with elevation gradients for all living organisms (Bhattarai *et al*., 2004). Four major ecological factors produce several microclimatic niches for the growth of lichens in the Western Ghats such as substrate, vegetation, climate and altitude (Nayaka & Upreti, 2011). Excluding nutrients and water, many factors are functioning for the gradual growth of all kind of organisms, like Climatic factors from temperature, humidity, nutrient allocation of other microorganisms, ultraviolet energy, and rainfall are varied in fluctuating levels at diverse agroclimatic zones in the forest ecosystem (Funnell & Parish, 2001). These factors are most important and responsible for the richness and physicochemical parameters.

Species richness is a dynamic account of communal and regional diversities in the forest ecosystem. The forest health's depends on the environmental parameters and the number of biotic and abiotic elements, which determine the community structure of massive for floral and faunal diversity of species (Schmidt & Brasseur, 2006). Forest fires are significant disruptions to all types of tropical forest ecosystems and contribute to the destruction of biodiversity (Aptroot *et al*., 2014). The negative impacts of the global impact are climatic changes leads to the landslide, volcanos, forest fires, floods in heavy rainfall are the significant frequency of the global climate changes. A better understanding of the complex fire dynamics at the regional level using a multifaceted approach is essential. The main reason for this is that thousands of hectares of forest lands and resources are destroying by fire every year (Hark-Soo Song & Sang-Hee Lee, 2017). Lichen community is an essential component of the biodiversity, including tropical forests, which regulates vital network services, such as nutrient exchange, atmospheric nitrogen determination, water management, and soil formation (Gradstein & Costa, 2003). They are one of the flora's dominant components, and it accumulates about eight percent of the terrestrial ecosystem. Extreme biotic and abiotic environmental stresses can survive well, such as low to high temperature, desiccation, and nutrient status (Ahmadijan, 1993).

The Southern Western Ghats, this part located in the Palghat gap (Southern Kerala) to the excellent peak point of Kanyakumari (Tamil Nadu). Although the wet zone's fauna is unique, India's the Western Ghats, the northeastern part of Sri Lanka, especially the Thrikona Mountains, are similarly stable (Gunawardene *et al*., 2007). Geologists and Biologists where the natural evolution had been studied about the movement of tectonic plateaus. Various studies on plant species between India and Sri Lanka have been conducted, and comparisons of the evolutionary biology of biologists worldwide. Originating a large number of species accumulation has found in 1753 by Carl Linnaeus in Species Plantarum. After many research, the researchers were recorded nearly 80% of the floral diversity from both places with great density. There are many threats to the living and non-living organisms of the forest and terrestrial communities (Favero-Longo & Piervittori. 2010). Several parts of the global diversity have decreased from different climatic and silviculture challenges. The majority of classified and enumerated species community's strength has entirely negative ranged. Because of the enlighten growth of human development and industrial usages of all aspects. The study has chosen to weigh the lichens density, richness, and distribution during multi-typed forests on different seasons at a negligible part of the Southern Western Ghats (SWG) in Tamil Nadu. First attempt to correlate between the lichen population and species richness with the natural and silviculture challenges, the intermediate population of them of SWGs and added few records of the State and regional lichen flora for the tentative site.

MATERIALS AND METHODS

Study area

This study has conducted on a part of the southern western ghats (an Indian biodiversity hotspot) namely the Suruli waterfalls forest in the neighbourhood place of Mullai river (Surabhi nathi) basin, the location is a small part of Megamalai wildlife sanctuary in Tamil Nadu and border of Idukki district, Kerala. Geographically, it lies between 9°34' to 9°36' North latitudes and 77°10' to 77°18' East longitudes covering an area of around 150 sq. Km. Here, the plain area covers almost 100 Sq. Km and mountainous forest area were sheltering 50 Sq. Km (Fig.1). There was a great number of floral and faunal diversity was estimated from long periods. Hither mega biodiversity accumulated with the shadowless density of the enormous old aged trees, corresponding as *Millettia pinnata* (L.) Panigrahi, *Tamarindus indica* L. *Ceiba pentandra* (L.) Gaertn. *Mangifera indica* L. *Bambusa bambos* (L.) Voss, *Tectona grandis* L.f. are the abundant trees in the area (Naveen Kumar and Sundarapandian, 2018). Red listed categorised species of animals noticed here, especially the Indian giant flying squirrel *Petaurista philippensis* (Elliot. 1839), Peninsular rock agama (diurnal lizard) *Psammophilus dorsalis* (Gray, 1831). An emblematic fly, crimson marsh glider *Trithemis aurora* (Burm.) (Burmeister, 1839), are the epidemiologic living organisms of the Suruli falls. One of the oldest and familiar Tamil legendaria's historical landforms has wholly covered with a variety of rocks for example granite, glacial, siliceous, igneous, sedimentary and metamorphic rocks types. During collection, surprisingly uninformed rainfall has observed, including summer. This study discusses weather parameters, such as minimum and maximum temperatures, relative humidity, sunshine and rain parameters related to the lichen growth fluctuations and its natural life threats.

Plot allotment and observation treatment

The lichens are well-known organism for linear growth habitat, and it holds vast diversity, but not only in the

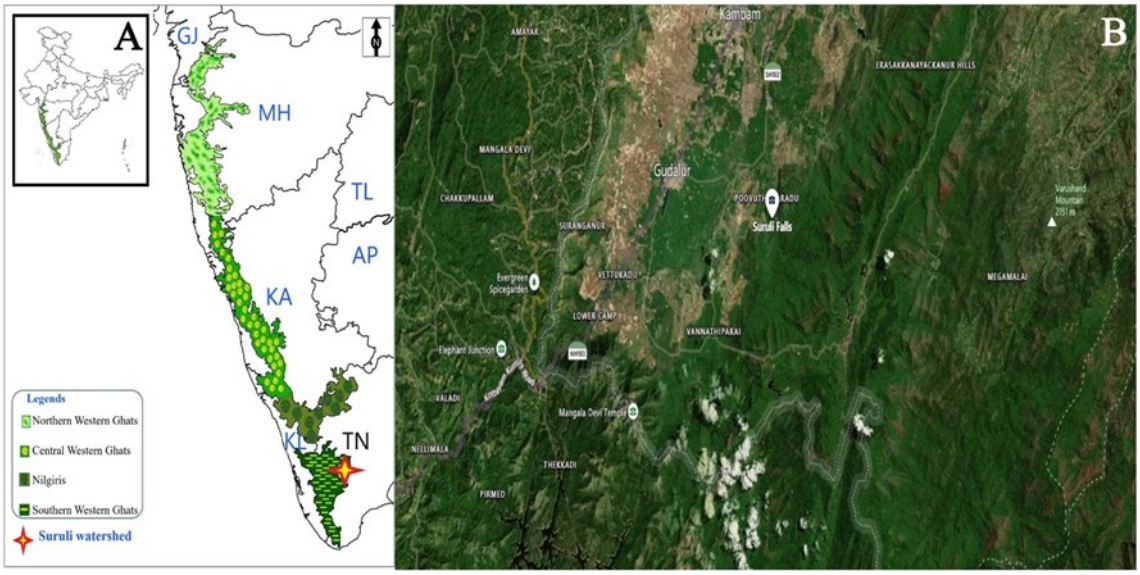

Figure 1a. Suruli falls of South-Western Ghats in Tamil Nadu, India, (**1b**) Suruli water falls.

hidden area, many of them from open places. Those samples documented with the 25×25 meters plot for each sample collection sites from the field. Every two months, once the site monitored from the occurrence and absenteeism of the lichen's species with growth rate (Sharma, 1995). Fluctuation of the numbers was distinguished and treated for statistical assessments such as alpha diversities, altitude ranges, and lichen growth within the group and outward. Many of the crustose listed as a slow grower, and few of the foliose are mid-fast, and the leprose are extremely fast-growing organisms. Altitudes are covering the communal growth and climatic factors basis richness. Based on, living and non -living substrates, density ranges were considered.

Sample collection and species analysis

From the field, lichen samples collected in the whole study area from six type habitats. Only the mature thalli have gathered for nomenclature process. Meteorological data(s) for example Climatic factors such as annual rainfall, minimum and maximum forest temperatures, Relative humidity, and sunshine data have received from the district head quatres, Theni in Tamil Nadu. For the six seasons (Monsoon, Autumn, Late Autumn, Winter, Spring and Summer), every two months examined for the population density and species reductions. Around 350 m (meters) MSL to the top of the hill (1650 m MSL.) was passed. We have treated Morpho-Chemo and anatomical characteristics to complete the lichen species' nomenclature analysis for identification purposes.

Lichen sampling procedure

Lichen population and limitation of diversity has considered for six seasons based on the climatic conditions from April 2018 to March 2019. Samples considered into three groups anddifferent forms (shapes and structures) such as Crustose, Foliose and Leprose. Total Samples considered by the Belt transect method (Sharma, 1995; Kalb *et al*., 2016). Four transects are covering 25×25 Sq. Meter quadrats for the available substrates. Such as corticolous, folicolous, lignicolous, muscicolous, saxicolous and terricolous (Divakar & Upreti, 2005; Wirth *et al*., 2009; Boch *et al*., 2013).

Identification of lichen samples

From the field few samples have been obtained to the lab for identification, basis on developed structural appearances. Those are allowed to treat on macro-morphological, microanatomical, assessing lichenoid-acids (secondary metabolites) for colour spot tests, micro-crystallisation and Thin Layer Chromatographic (TLC) techniques were used (Awasthi, 2007; Orange *et al*., 2001; Culberson & Ammann 1979; White and James, 1985; Steiner, 1955; White & James, 1985). The recent classification for lichens and lichenised fungi were classified based on standard nomenclature methods (Feuerer & Hawksworth, 2007; Nordin *et al*., 2011; Lücking *et al*., 2017; Ghiyasi and Sohrabi, 2019). The identified species deposited as voucher specimens at the Nationalised lichen herbarium (LWG), CSIR- National Botanical Research Institute, Lucknow, Uttar Pradesh in India.

Data analysis

Eco-lichenological ranks premeditatedly founded on altitude, geo-specificities, substrates or habitats and morpho-types. The samples species richness, family density, and diversity parameters such as alpha, beta diversities, and indices calculated for various assessments (Condit. 2002; Ulrich, 2020; Simpson, 1949; Pielou, 1975; Pielou, 1977). Species rarefactions and meditation were with seasonal weather parameters have supervised by using biological statistic tool Past 3.1. Seasonal parameters of averages of temperature, rainfall, and humidity fixed by the Köppen primary classification (Chen & Chen, 2013). The obtained meteorological data subjected to analysis using One-way Anova through Duncan's multiple range tests using SPSS 19.0 package (Gomes & Gomez, 1984).

RESULTS

Lichens can grow on any substratum with an optimal and adhesive favorable condition. From this case study, the substrate affinity calculated by the available sources. Here, Only *Chrysothrix chlorina* have found on all kind of substrates. The least diversity has observed on the *Diorygma hieroglyphicum*, *D. junghuhnii*, *Pyxine coccifera*, and *Rinodina mackenziei* on the corticolous substratum. *Cratiria obscurior, Pyxine cognate* and *Rinodina sophodes* accumulated on both the

Table 1. Morphological parameters and species density at Suruli watershed

Name of the Lichens	ACCES-SION NUMBERS	CODE	SUB-STRATES / HABITAT*	TYPE OF THALLUS	TOTAL
Chrysothrix chlorina (Ach.) J.R. Laundon	19-36108	CC	All	Leprose	6
Cratiria obscurior (Stirt.) Marbach&Kalb	19-36102	CO	C, S	Crustose	3
Diorygma hieroglyphicum (Pers.) Staiger&Kalb	19-36089	DH	C	Crustose	4
Diorygma junghuhnii (Mont. & Bosch) Kalb, Staiger&Elix	19-36057	DJ	C	Crustose	12
Lepraria ecorticata (J.R. Laundon) Kukwa	19-36058	LE	C, S, L, F, M	Leprose	8
Parmotrema tinctorum (Despr. Ex Nyl.) Hale	19-36059	PT	C, S, T	Foliose	6
Pyxine coccifera (Fée) Nyl.	19-36059	P.Cf	C	Foliose	1
Pyxine cognata Stirt.	19-36108	P.Cg	C, S	Foliose	3
Rinodina mackenziei Räsänen	19-36060	RM	C	Crustose	2
Rinodina sophodes (Ach.) A. Massal.	19-36061	RS	C, S	Crustose	4

(Habitat*: C-Corticolous; S-Saxicolous; L-Lignicolous; F-Folicolous; M-Muscicolous; T-Terricolous and All- Whole substrates)

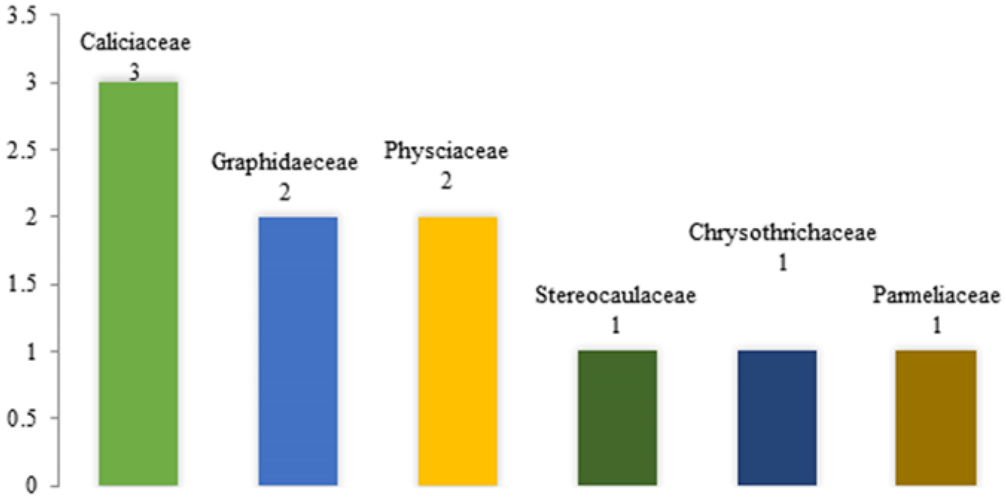

Figure 2. Lichen species richness in different families

corticolous and saxicolous condition. *Parmotrema tinctorum* found on Terricolous (reddish white clay soil). *Leprariae corticata* has found on the Corticolous, Saxicolous, Lignicolous, Folicolous and Muscicolous. From this mega diversity were found on corticolous and least diverse were noticed on Terricolous. For the first time on distribution, the analysis carried out for species density, richness and lichens diversity have noticed at Suruli watershed, have its place to the Cumbum Delta belt of the Southern Western Ghats in India. The results indicated that 49 samples from the ten species have collected on different substrates (Table 1). Among the six other families, *Caliciaceae* (3) found to be prominent, followed by *Graphidaeceae* (2) and *Physciaceae* (2), each one from *Stereocaulaceae*, *Chrysothrichaceae* and *Parmeliaceae* have collected on the experiment site.

Six types of growth forms were observed throughout the world, but this study conflicts only three types such as Crustose, Foliose and Leprose. However, *L. ecorticata* was found to be the maximum recognized species as an unstable form, confusing either crustose or leprose. The Substrate affinity and thallus specificity have described briefly in Table 1.

All the samples have been collected from various living (on tree barks and leaves) and non-living habitats (on tree trunks, fallen trees, rocks & soil) and it covers six seasons of the entire year. From six different growth forms, Crustose are abundant with five species. Foliose are familiar with three, and leprose is least with two species. Nevertheless, the fruticose, squamulose and dermatoid types are absent. Leprose are only two, such as *Chrysothrix chlorina* and *Lepraria ecorticata.* From crustose *Cratiria obscurior, Diorygma hieroglyphicum*, *D. junghuhnii*, *Rinodina mackenziei* and *R. sophodes* are morphologically different, and the occurrence of secondary metabolites also verified. The foliose such as *Parmotrema tinctorum, Pyxine coccifera* and *P. cognata* are entirely different and leafy structured. Only one foliose (*P. coccifera*) and two crustose species, such as *Diorygma hieroglyphicum*, *Rinodina mackenziei* have gathered from the ten lichen species for the first time in Tamil Nadu state from the study area. Those three species are additional records for the Tamil Nadu State Lichen Flora, and the *R. mackenziei* was recorded as a new to Western Ghats biodiversity hotspot. In total only one (*P. tinctorum*) was edible and it collected by the

indigenous and tribal community (Paliyaa's) people from corticolous and saxicolous habitats. Nevertheless, only when it matured and detached from the substrates. They do not use other species as spices.

The substrate affinity or accumulation density (Figure 3) of lichens was profound in corticolous with 3.25 than saxicolous in one. However, the terricolous is least with 0.02. Lignicolous and muscicolous are comparatively less (0.3) than the folicolous (0.5). Only from six to seven percentages determined. The corticolous lichen species such as *C. chlorina*, *D. hieroglyphicum*, *L. ecorticata*, *P. coccifera,* and *P. cognate* was abundant from the field.

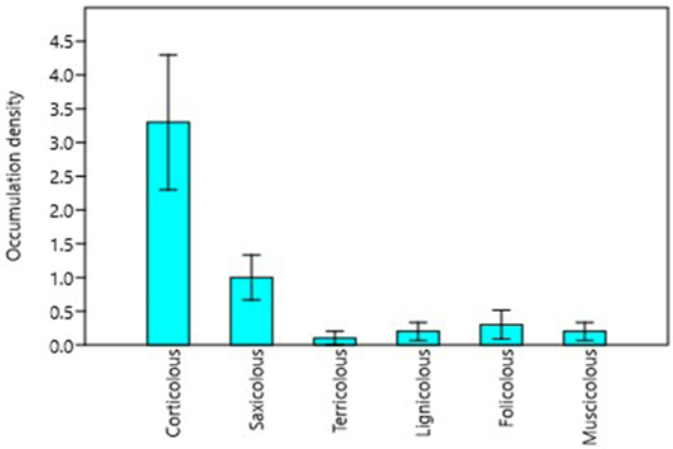

Figure 3. Substrate affinity

Species richness have determined as stock for all collection season. The *C. chlorina, D. junghuhnii, L. ecorticata* and *P. tinctorum* found to be more abundant than *P. coccifera, P. cognata, R. mackenziei* and *R. sophodes* in all the seasons (Fig. 4). *D. J* is more diverse in all seasons, *C.O*, *D.H*, *P.C f*, and *R.M* are very less populated for all seasons. This *L. E* and *P. T* are gradually increase its population for all six seasons. All the samples are found more at summer season. But in Monsoon and Autumn seasons the sample number is very less. It was increasing gradually on Winter season. The large numbers were noticed on the summer season.

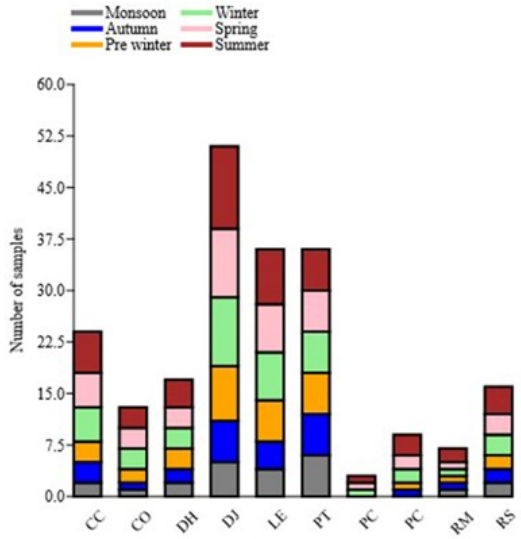

Figure 4. Number of species occur on the study area; 10 species are considered for six seasons in the species richness.

Diversity of the lichen population has considered for the altitude ranges. Existing of *C. chlorina* and *R. sophodes* were rich at 430, and 435 m above mean sea level (MSL), respectively, and *L. ecorticata* found at 401 m and other species found in the range of between 408 and 418 m above MSL (Figure 5). Collected the samples from the maximum has made from the 405 to 430 above MSL only. Nevertheless, the species density was more active at the shade condition, and crustose, leprose or foliose samples were most active in sunny areas.

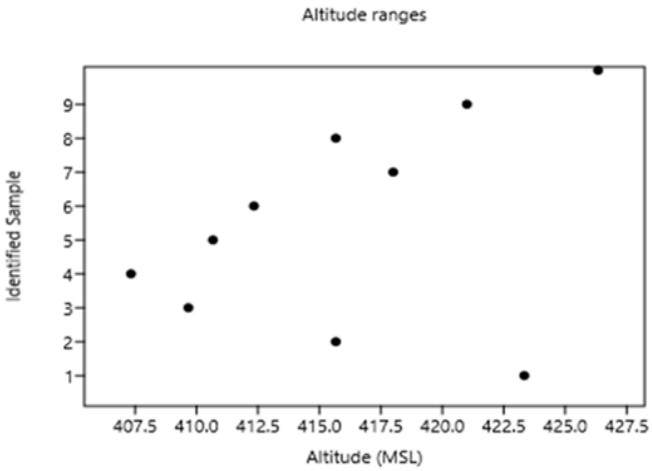

Figure 5. Altitude ranges of all lichen species.

The familiar powdery lichens such as C.C and L.E. have found in top places in all forest areas. This L.E. has not found in the terricolous condition, but other substrata have balanced growth. P.C. and R.M. have linear growth between the climate and substrate. Nevertheless, it is the regional additions to the lichen flora.

Shannon index (H')

This richness of species was usually abundant on various living and immovable organisms. Such as plants and animals were suffering from the high amount of temperature and heavy rainfall. This lichens species is not suffering from those reasons. It will be more active in the monsoon and spring seasons; it was completely stable for the summer season's survival conditions. From the obtained result, this lichen species is more active in the winter and spring seasons, but in numbers, summer is more. During the monsoon season, samples decrease gradually for the significant reason for detachment and misbalancing of the thallus' holdfast or rhizines.

Lichen species diversity was measured using the formula for the number of individual species in each lichen genera. The relative abundance of lichen distribution was deliberated based on the number of species in the study site; the diversity index represented each community and increased species density during the whole period.

$$H' = \sum_{i=1}^{k} pi \times lnpi$$

K is the total number of lichen species, and *pi* is the proportion of individuals species *I* contribute (Figure 6a).

Simpson 1-D

The samples' significant losses during the high templated seasons such as spring and summer are most of the living species such as plants, animals, insects, and birds, which are misplacing their lives, demanding the required amount of water and nutrients. However, these lichens are stress tolerated because the fungal partner stores the food materials to survive a long time: more than two times, flood shooed out from the Suruliyaaru river and manalaaru river. In the monsoon, this field has received more amount of rainfall than the usual amount. At that time, this area wholly prohibited for tourists, visitors and the local public. This summer season, the samples dominance was 0.856, and the least received on monsoon (0.832); the stable condition occurred on the spring and winter seasons (0.851) represented in Figure 6b.

Pielou Index (J)

The standard measurement of the evenness of species community is called Pielou's index. It measured by the number of predominant populations, which is relatively constant in inhabitants. The number of individuals in each community and abundance of most abundant species in the total population also recorded **(**Figure 6c**)**.

Dominance (D)

The samples found from various substrates and different seasons on maximum to minimum in the field; in Alpha diversity analysis, this dominance has derived from the maximum at monsoon (0.17) and lowest on summer (0.14). Usually, the plant samples are decreasing in the summer season but not in cryptogamic lichen species. Especially the crustose variety was unexpectedly more growth has observed on the summer season only. The leprose variety has an excellent facing loss on the monsoon and autumn seasons (Figure 6d).

***Formula*:**

$$D_{BP} = N_{max} / N$$

N = Total accumulated samples in the whole community
N_{max} = Total number of maximum available common species

Sample rarefaction

Sample's rarefaction has described the samples' seasonal availability from the field on different types; Mao's tau test considered the calculation between the presence and absence of the lichen species from the sample rarefaction. This measurement has considered with 95% confidence level. Several taxa considered from season 1 to season 3 (9.333<9.8<9.95), after the samples are increasing gradually with standard errors (0.48305>0.18974>0.047434), If the samples detached from the substrate, the new or next generation of the sample was growing naturally (Figure 6e).

Survival probability analysis

The lichen community's survival probability has recentred for seasonal variation as per Kaplan-Meier plot, least amount for monsoon season in average time is 2.3, and moderate hazard is 0.13043, the maximum obtained from Autumn season with 3.2. The average hazard is 0.0625 has tested (Figure 6f).

Diversity analysis

Unique richness deliberated from the whole seasons from 23 to 49 samples of the identified ten species. The maximum numbers of samples collected from the Suruli falls field are 49 samples, and the least amount was available from the monsoon season. The winter and spring season gradually the same density of samples 42 has observed (Figure 6g)

SHE analysis

It examines the differences and relationship between the species richness (S), Information of the Shannon-Weiner diversity index (H) and evenness as measured using the Shannon-Weiner evenness index, otherwise known as Pielou J (E) in the samples. It is therefore an approach to look at the contribution of species number and equitability to changes in diversity. SHE analysis follows the way these parameters change with increasing sampling effort (Figure 6h).

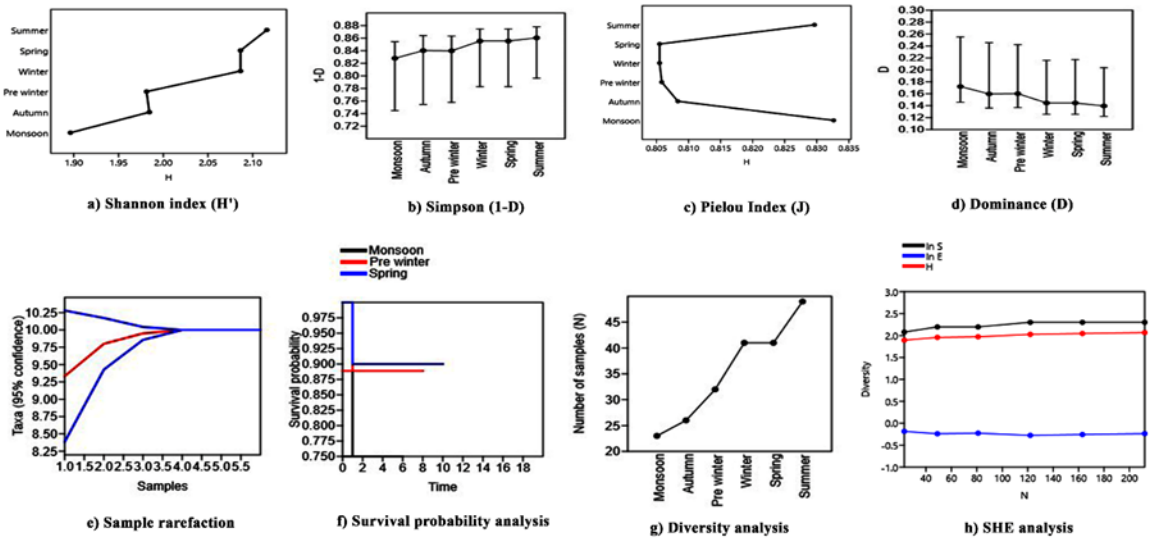

Figure 6 (a-h) are comparatively consolidated with 95% confidence from the Eco physiological assessments.

Individual rarefaction

The Lichen population were functioning behind the natural calamities such as Windspeed, atmospheric nitrogen, nutrition factors, water and so on. But this individual growth of the population is depending on various hazardous factors. Whether, from naturally or manmade hazards. This case found for this result in the profound and profusely on uneven manner (Figure 7).

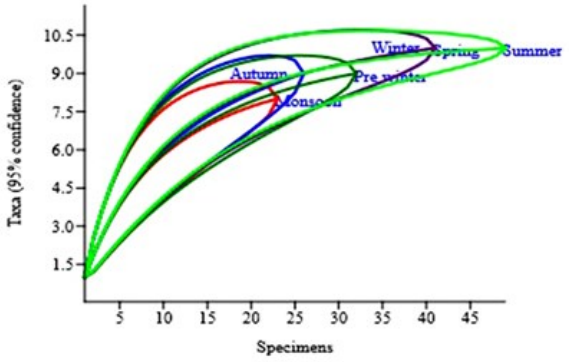

Figure 7. Individual rarefaction

Study site overall richness

Species indices have statistically analysed various seasons, which indicated a significant variation in Simpson's Index, Pielou's Index and Shannon Index at SD. p>0.005 in terms of lichen species richness (Table 3). The Survival analysis of each species on various seasons have determined based on the Kaplan-Meier plot method, and it resulted in (Figure 8). From the six-season, the samples' availability has assessed in the spring season compared to prewinter than monsoon.

There was a positive correlation between weather parameters and the lichen population (Table 2). The environmental variables revealed that the lichen density was more about spring to summer (27.3 to 25.5%) seasons. 23.5 to 18.5% during the winter and late autumn periods. Compared to existence and low population level, it ranged between 13.5 to 11.3% during Autumn and Monsoon, which is the highest percentage of density registered during mentioned periods. Similarly, the high number of unique species richness

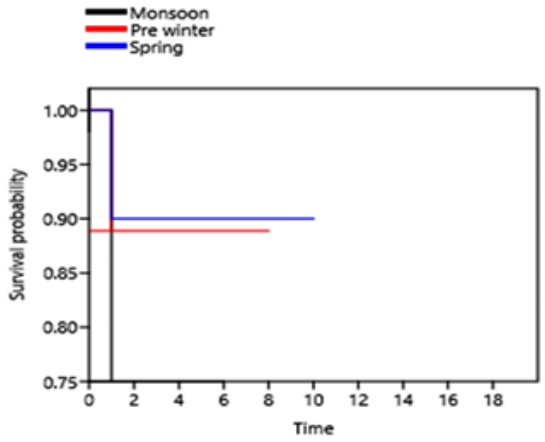

Figure 8. Study site overall richness (Kaplan-Meier plot)

observed in summer and spring and lesser numbers in Monsoon, autumn seasons (Figure 9). The abundance of lichen positively correlated with minimum temperature and maximum relative humidity, ranging between 13.7 to 17.3ºC and 87.3 to 98.5%, respectively, from June to December. During the same period, the mean of sunshine was 3.3 to 4.3 hrs/day, and the total rainfall between 116.4-1138.4 mm coinciding with the lichen population (Table 2).

A maximum number of samples have recorded around 27.3 pieces in spring followed by Summer (25.5) and winter (23.5) seasons. The number of lichen populace found to be least in monsoon, which is document approximately 11.3. The abundance of growth in lichens observed in rainy seasons. From summer, the lichen's fruiting bodies are very proactive.

DISCUSSION

During the study, many lichen species has observed in a single habitat, some species formation for the biodiversity studies corresponding to well-distribution observed, based on the rainfall, and good soil fertility. It has occurred on *Terminalia arjuna*, *Ficus benghalensis*, and *Mangifera indica* trees found to be the megadiverse and more gigantic trees in the Suruli waterfall area (Naveen Kumar and Sundarapandian, 2018). Similarly, the granite and glacial rocks are more diverse, and the

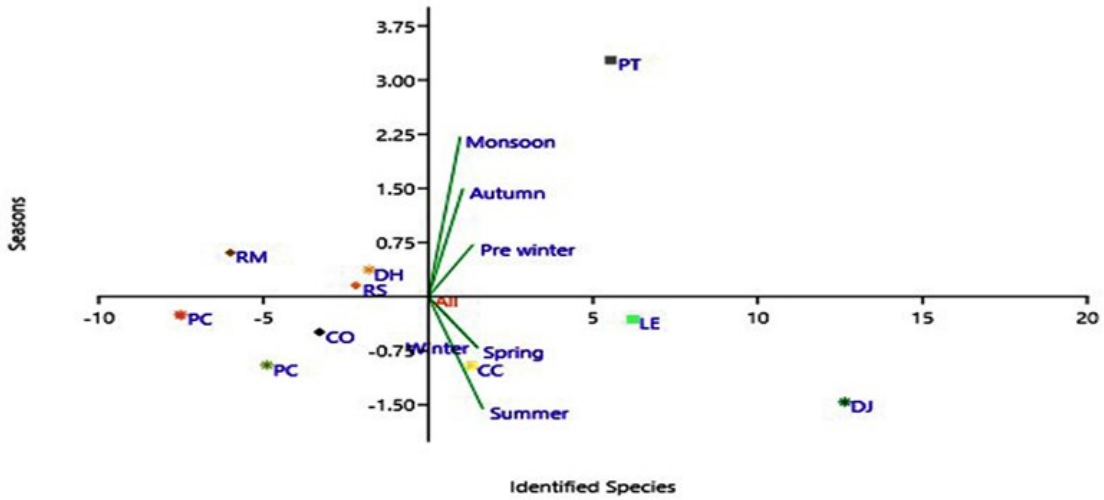

Figure 9. The overall population was evaluated with the PCA plot with total collected specimens for six seasons.

Table 2. Seasons based climatic factors of Suruli watershed

Season		Months	Sun shine (Hrs/ day)	Minimal and maximal Temperature (ºC)	Avg. rainfall (mm)	Relative humidity (%)	Species Accumulation density (%)
Season 1 (Monsoon)		April to May (2018)	6.6 to 7.2	25.0 17.0 25.0 16.7	1138.4 ±11.3 941.7 ±13.5	69.0 to 54.3 76.5 to 60.0	8.6
Season 2 (Autumn)		June to July (2018)	9.4 to 9.8	22.3 17.3 22.7 16.7	998.2 ±13.0 918.6 ±25.5	68.5 to 56.0 62.3 to 54.7	9.4
Season 3 (Late autumn)		August to September (2018)	10.6 to 11.2	20.7 15.5 20.3 14.7	854.8 ±21.5 890.3 ±11.5	88.7 to 67.7 68.7 to 61.7	12.7
Season 4 (Winter)		October to November (2018)	12.6 to 13.4	21.7 13.7 22.5 15.3	154.6 ±18.5 116.4 ±15.0	88.3 to 79.5 87.3 to 74.3	18.5
Season 5 (Spring)		December to January (2018 - 2019)	14.6 to 14.6	23.3 15.7 25.5 17.3	22.0 ±23.5 14.2 ±22.7	96.7 to 90.7 95.7 to 84.3	25.8
Season 6 (Summer)		February to March (2019)	15.2 to 13.4	30.3 19.7 30.7 16.5	19.7 ±27.3 19.7 ±24.5	98.5 to 88.3 94.7 to 83.3	24.9
Standard error ±		-	0.89	3.65	0.88	-	0.88
Calculated at 5%			1.78	5.98	1.89	264.46	1.82

siliceous covering igneous, sedimentary and metamorphic rocks types also noticed, but less in numbers. More numbers of species are avail on Trees and less in terricolous condition. The luxuriant growth of lichen thalli has notified on the rainy and Autumn seasons. Meanwhile, the crustose group of fruiting bodies flourished during the summer season. Moreover, the thallus falling were noticed from the corticolous, saxicolous and terricolous. It is obviously due to the high temperature and low moisture content in the forest atmosphere. The report further indicated that lichens could survive well in the pH ranges of 4.3 to 5.5 in sliver oak tree barks and 4.5 to 6.0 in rock samples (Asta *et al*., 2002).The moisture content and pH profoundly influenced the substrate's lichens with the adhere capacity, which helps plants-symbiont interaction (Inderjit *et al*., 2005).There was a close relationship between the moisture content and pH value of different substratum (tree bark and rocks) and the number of lichen colonies considering the substrate attachment. Plants interact with other species such as moths, insects and other microorganisms, but this lichen interacts with permitted and low healthy tolerant plants. That influences the plant-lichen interaction (Bajpai & Upreti, 2020). Lichen and host plant interaction and secondary metabolites inhibit the contents like chlorophyll and carotenoid in spinach through oxidative stress produced by the corticolous lichens (Bouaid & Vincent, 1998). The hyphae of the mycobionts penetrating the xylem vessels of the silver oak (*Quercus rotundifolia*) trees and leads to deposition and chlorosis diseases due to oxidative phosphorylation. One of the finding species *chrysothrix* has reported earlier with the symbiotic virus combination at ČeskéBudějovice countryside in the Czech Republic (Petrzik *et al*., 2019). However, this study considering the morphological and chemotaxonomical characters with diversity challenges.

The terrestrial forest habits occurring on the cryptogamic and phanerogamic plants, including lichens. Throughout the world, without human intervention, it is because of the conducive interaction of the atmosphere in the forests and enormous vegetation (Gerson and Seaward. 1977; Elbert *et al*., 2012). It reported that the cryptogenic plant-like lichens and bryophytes could help fix the atmospheric nitrogen on the soil surface, rocks and plants by nature. North American and European unions were showed more richness in unmanaged than in conserved forests (Boch *et al*., 2013). The routine assessment has derived for small amounts of mist or rain could be more optimal for the growth of most lichen species than rare massive rainfall events, which may explain the lack of correlation between species richness and maximum rainfall (Mohammed *et al*., 2016). The ecological diversity of lichen species has studied by calculating species diversity by mean of the suitable indexes, relative abundances of the variety for the ten species in the experimental like based on presence and albescence during the

sample collections. The interface of characterising the species richness derives the conservation interest and contribution to the segregation of a particular site for species protection. These findings inferred those lichens are the best indicator of the forest's pollution and natural health evaluator using lichen as a modern biomonitoring biological tool.

A few species from wealthy families are *Caliciaceae*, *Graphidaceae,* and *Physciaceae,* dominant in the communities, both in abundance and richness. Thus, the result reported by Bury *et al. in*2018. They further requested a significant relationship between the elevation gradient and abundance of species richness and climbers' composition in the tropical forest community (McVicar & Körner. 2013). Community-level, *Caliciaceae* members found the most abundant and most prosperous functional group of the selected study site. Species richness had to be the least in number and low altitude areas of the Suruli watershed. Because of Tamil Nadu forests' extreme temperature level and low relative humidity in the air, and extensive sunshine. Allelopathic effects of lichens studied by Bajpai and Upreti (2020). They reported that lichens' secondary metabolites affect different substrates' surface such as rocks, soil and tree's barks and leaves. Already many pieces of research revealed that the correlations between human community and diversity.

Most of the habitat forms are corticolous only, but in rare condition, the terricolous and lignicolous types found. Comparing the young trees and their branches, very few collections were noted, but the old and gigantic trees and their components were households for all kind of lichens. *Pyxine coccifera* found on corticolous. Meanwhile, the piece was conjunct with *Parmotrema tinctorum*. Variety of rock substrates espousing many of the leprose and foliose models. Nevertheless, only the *Crateria obscurier* has collected from the silicosis rock nearby the river. Many samples accumulation noticed on the Leprose types; both *Leprariae corticata* and *Chrysothrix chlorina* species found many on all kinds.

Silviculture process and human communal disturbances

During the collection period, there are different climatic changes have been observed. The diversity of lichens has a negative impact against the plant growth level. Usually, the density of plant species has increased in the Autumn and winter seasons. The human population's routine access for religious activities and sacred groove prayer will be more during rain than summer. In the winter season, the enchanting for the seasonal prayers, especially during Seasons 4 (Winter), 5 (Spring) and six (Summer). Nevertheless, these crustose lichens are flourishing in the summer season only. The foliose and leprose are entirely dormant in the summer. However, this leprose and foliose were fallen from the substrate during the heavy rainfall season. Spring and winter are an excellent time to increase the development of all types of lichens. Especially the corticolous varieties are a perfect habitat for all growth forms of the lichen communities. Most of the forest has broad leaf plants such as *Tectona grandis* L. f. and *Gmelina arborea* Roxb. etc. In the summer season, many possibilities are available for the forest fire, and the gigantic rocks can be falling on the monsoons. *i.e.,* neighbouring part of the study area in western ghats, during the late autumn season (August 7th 2020) in Idukki district, a part of Kerala faced a landslide accident before red alert of heavy rainfall, and 24 died, and forty labours settled inside the soil at Rajaamalai near Munnar (Indian express, 2020). Therefore, it is difficult to know whether exotic species dominated these lowland assemblages of the endemic or unknown taxa reached the island together with exotic native plants. In 2018 this same part of southern western Ghats (Kurangani) had stuck with a forest fire, and 26 youngsters have died. However, there is no data for the loss of trees and living organism. Almost 50 acres of middle forest area have burned. There is no permission to access the common public and vehicle mobility. There were strictly restricted to enter inside the forest, but few unauthorised trekking agents made this attempt for the Innocent I.T. workers and their family members (Arockiaraj, 2018). Humans utilise more parts of the global area, including water, energy and forest land's living things with mines and trees. It leads to thrives of the other living organisms and land area. Approximately 20% of the land area destroyed per decades for/by human interactions and manipulation activities (Dianzinga, 2020). By the way of deforestation, density of forestland and tree cover was falling down without any restriction by the natural and manmade calamites.

CONCLUSION

From this study, we concluded that three lichens species have been added into the Tamil Nadu state lichen flora and one species was an addition for the Western Ghats. These lichens are playing as a modern biomonitoring and health parameter tool of the forests. The data was obtained and assessed for six seasons with valuable pieces of stuff in understanding the importance of lichens and allelopathic and anthropogenic effects. The communal richness and forest diversity were dropped due to various reasons such as human encroachments and natural disasters. The tribal communities restricted to the particular area are always protected the communal richness of the forest without disturbing it. In general, tribals were used lichen resources sustainably from fallen condition not from the substrate. Further studies will be carried out the other licheno-geographical regions in all over India.

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AUTHOR CONTRIBUTIONS

N. Rajaprabu designed the research, collected, analysed data, prepared figures, and wrote the manuscript. P. Ponmurugan co-designed the research work and assisted in writing. The lichen's Voucher Samples were deposited at CSIR-NBRI, Lucknow in India.

DISCLOSURE STATEMENT

The authors reported no conflict of interest.

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