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Lichen-host plant specificity on citrus plant species in coastal agroecosystems at No. 63 Benab, Berbice, Guyana

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Abstract

This was a preliminary study into host-plant lichen specificity at two coastal agroecosystems sites at No. 63 Benab, Berbice, Guyana. For each of the two sites, sampling plots of 2000 meter square (2000 m2) were demarcated and at 50 m × 40 m study plots were established. Healthy mature trees were identified in each plot to assess the lichen communities host-plant specificity. Twine was used to mark the trunks of 40 healthy individual trees in the North, South, East, and West quadrants (each measuring 50 by 100 cm). A total of 52,311 lichens were recorded and these were placed into fifteen (15) families, twenty-three (23) genera, and thirty (30) species. Crustose lichens were the most abundant in the study. Cocos nucifera had the highest average number of lichens recorded and accounted for forty-five percent (45 %) of the overall host trees that were sampled. Four (4) species of lichens (*Flavoparmelia soredians*, *Dirinaria applanate, Lecanora muralis* and *Lecanora conizaeoide*) showed specificity towards all host trees in the study. Twenty-six (26) species did not show specificity to all twelve (12) of the host tree species sampled. Twelve (12) species of lichens (*Parmelia sulcata, Flavoparmelia soredians, Flavoparmelia caperta, Dirinaria applanate, Chrysothrix candelaris, Lecanora muralis, Lecanora conizaeoide, Arthonia cinnabarina, Arthonia purinata, Candelaria concolor, Lepraria lobificans* and *Graphis elegans*) showed host tree specificity for four (4) species of citrus trees sampled. 13.3 % species were found on all tree hosts: *Flavoparmelia soredians, Dirinaria applanate, Lecanora muralis* and *Lecanora conizaeoide*. *Mangifera indica* hosted 76.7 % (23 of 30 species) of all recorded species. *Tamarindus indica* hosted the least number of lichen species, 26.7 % of lichens (8 of 30 species). Given that a lot of development is considerably taking place in the coastal areas of Guyana which may increase the instances of pollution, studies of this type can be beneficial since prior research has established the importance of lichens as good indicators of air pollution.

Keywords: Lichens; Host Plant Specificity; Citrus; Coastal ecosystems; Guyana

1. Introduction

Lichens tend to show preferences to certain tree species which they select to dwell on [6] [9] [25]. This can be influenced due to the nature of the bark and even its microclimatic and chemical conditions [9] [61]. When studying lichen ecology and distribution, understanding host specificity is important and essential knowledge on the degree of specificity can be useful when estimating and monitoring lichen diversity for their conservation. Substrate factors can influence the lichen distribution depending on geographic region, forest types and species of phorophyte (host) [9] [61]. Some lichens prefer certain trees, which may be due to a variety of factors such as the nature of the bark, microclimatic conditions, and chemical circumstances [6] [7].

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Rosabal *et al*., 2013 reported that appearance, links between water and the chemistry of plant bark, including pH, are essential substrate characteristics that determine lichen distribution. In 2003, Gradstein *et al*. claimed that the coarse-texture of the bark is an important aspect in the creation of lichenized symbionts. Bark moisture is another factor that determines lichen distribution; however, this parameter can be constantly changing even on the same tree since microhabitats and microclimates vary depending on the height of the tree [9] [51] [61]. Subsequently, some inorganic and organic substances, ash content and the bark's pH might affect lichen distribution due to the chemistry of the bark. However, even though phorophytes are of great importance, certain factors can still affect lichen distribution, but there is minimum verification regarding the specificity of lichen-phorophyte in certain forests in the tropical regions [9] [51].

Lichens are known to live in almost all terrestrial habitats and they even thrive well in aquatic habitats [9] [16] [44] [48]. Lichens are well known for their ability to colonize on both varying substrates of artificial and natural creation. Natural lichen substrates would include peat mosses, tree bark, rocks, wood, soil and even on other lichens, the shells of tortoises, backs of sloths and certain insects and broad evergreen leaves. Artificial substrates where lichens can be found include plastic, glass, metal, concrete and cloth [9] [12] [48].

Lichens are capable of growing on almost any stable surface and some vagrant, or tumbleweed lichens grow unattached, drifting over soils found in the arid regions. Lichens that grow on wood or bark (even natural fencing materials) are termed epiphytic lichens [9] [16] [44] [48]. The type of substrate is also used as a basis for characterising lichens. Foliicolous lichens grow on the leaves of vascular plants, corticolous lichens grow on the bark of living plants [9] [12] [48] [55]. Saxicolous lichens grow on rocks and can be categorized into two (2) distinctive categories; siliceous (inhabit acidic rocks) and calcareous (flourish on calcium rich basic rocks like limestone or cement and even sidewalks). The terricolous lichens grow well on soil [9] [12] [16] [44] [48]. Terricolous lichens growing together with moss and free-living cyanobacteria aids in the formation of biological soil crusts, or simply biocrusts, and they are important soil enhancers and even work as stabilizers in various desert ecosystems [9] [16] [44] [48]. In the year 1988, Lücking used the term 'plasticolous' and this was used to refer to lichens that grow on plastics.

Lichen habitats are varied and they can survive in a distinct setting and their development can be influenced by many abiotic factors, such as accessibility of moisture, light, wind velocity and temperature [8] [9] [10] [21]. Lichens have resistant species that can survive in deserts that scorch and freezing tundra. There are two (2) main characteristics that are suggested to have a significant role in their establishment: their drying survival capability and their complicated chemistry [9] [10] [28] [41] [53].

Some species of lichens inhabit some semi-aquatic areas of marine tidal zones e.g., rocky shorelines, freshwater lakes, and mountain streams. The *Peltigera gowardii* is a specie of lichen that is previously known as the western populations of *Peltigera hydrothyria* (or *Hydrothyria venosa*) and they even thrive permanently submerged in areas like the spring fed mountain streams [9] [10] [16] [44].

Lichens and mosses tend to form a gradient, from mosses that are dominating areas that stay the wettest (though some lichens are present) and even lichens that are dominating areas that stay the driest throughout the year. Some gradients are often clear among the lichens themselves. The chlorolichen species inhabit areas such as the Pacific Northwest and California's north-coastal mountains, conifer forests. They have common mossy zone that is close to the ground; as they mature and long fruticose lichens known as alectorioid lichens (generally *Alectoria* and *Bryoria*) colonize the mid-canopy of trees; then as the old-growth conditions develop, cyanolichens will start to colonize a specific zone in the lower canopy of the tree, just above a mossy understory [9] [10].

Some lichens are specialized to smaller microhabitats. Some gradients can be found going around a tree trunk and mosses may dominate the wettest areas that receive the canopy drip, with larger fruticose and foliose lichens next in the gradient. The transitioning to sheltered areas that receive no direct liquid water, is where researchers may find a variety of powdery crustose leprarioid lichens and minute pin-lichens that possess tiny stalked fruiting bodies. These sheltered microhabitats are best developed in very old-growth forests. Additionally, very similar gradients can often be found elsewhere such as the face of a single large rock [9] [10] [29] [43].

In the cold Antarctica, very harsh climate and little vegetation are present with lichens being the most abundant species of organisms that are present with about three hundred fifty (350) species being reported from the Antarctic region [9] [10] [28] [49]. The fruticose lichen belonging to the species of *Usnea* genus and *Umbilicaria*, which is dominant in the Antarctic region, can reach heights of about twenty centimeters (20 cm) and are regarded as the biggest primary producers in these Antarctic biomes. Some of the crustose lichen thalli vary widely over the sandstone in form and size [9] [10] [19]. Lichens are capable of readily and rapidly drying up to ninety-seven percent (97 %) of water to become an anabiotic disease [10] [28]. Park *et al*., 2018 recently reported that *Psoroma antarcticum* was found in the Antarctica's

South Maritime Shetland and the South Orkney Islands. This new species is strongly linked to the lichen *Psoroma hypnorum* and it is quite unique in the cup-shaped apothecia, smaller ascospores, and thalli with gray-to-black melanin [9] [10] [42].

Some lichens might survive in some water-deficient environments for a long time and they may resume physiological functions when the conditions are appropriate and these are termed as poikilohydric lichens [4] [9] [10] [33] [64]. Lichens possess a special gene for drought resistance and its function can be understood by transferring the gene to other organisms that fight water-deficient issues anywhere around the globe [2] [9] [10] [20] [65]. Subsequently, different research had showed that because of the antioxidant capacity of lichens their drought resistance capacity was found to be dominant [9] [10] [27] [63].

A study by Logsdon & Carson (2010) reported that when compared to aspen or birch trees, sugar maples had the highest lichen variety. These differences were found to be very significant and the study also revealed that a number of distinct lichen genera were more frequently found on one tree species than on others.

Matwiejuk (2017) conducted a study in Podlaskie Voivodeship (North-Eastern Poland) to assess the variety of lichen species on fruit trees (*Malus sp., Pyrus sp., Prunus sp.,* and *Cerasus sp.*) growing in orchards, in particular villages and cities. The results of this analysis revealed fifty-six (56) different lichen species. On the trees, the heliophilous and nitrophilous species of the genera *Physcia* and *Phaeophyscia* predominated, which are frequently discovered on the bark of trees growing in inhabited areas. The lichen biota is more diverse on pears (36 species) and apple trees (52 species). This phorophyte inhabiting Polish fruit orchards has lichens from apple trees as 78% of its biota.

In a virgin Carpathian Forest, Vondrak *et al*. (2018) assessed hotspots and the useful identification of lichen diversity. Although they measured alpha-diversities of between one hundred eighty-one to two hundred twenty-eight (181-228) species, the estimated species richness is between two hundred seven to three hundred twenty-two (207-322) species. Three hundred eighty-seven (387) species of the detected gamma-diversity were also recorded, with estimations for the actual number of species ranging from four hundred nine to four hundred eighty-four (409-484).

Subsequently, in the year 2018, Roper conducted a study on the Lichen Abundance and Diversity concerning Host Tree Species and Lakeshore proximity. Based on the results of this study, the tree species was a much stronger factor in the diversity and abundance of epiphytic lichen when compared to lakeshore proximity.

Another study conducted by Rashmi and Rajkumar (2019) assessed the diversity of lichens along elevational gradients in the Forest Ranges of Chamarajanagar District, Karnataka State. From the survey, a total of ninety-seven (97) lichens, belonging to forty-seven (47) genera and twenty-five (25) families were recorded. This study concluded that the higher the gradient of the land, the more abundant, dense, and widely distributed are the lichens as one approaches the elevation of the mountain peak.

In 2021, Bacchus & Da Silva investigated the host plant specificity of corticolous lichens in urban and suburban New Amsterdam, Berbice, Guyana. Their study concluded that host plant specificity was observed for four (4) species of the recorded lichens where three (3) species were specific to *S. mahagoni* and one (1) species was specific to *C. nucifera*. Further, they documented a higher number of crustose lichens as compared to foliose, fruticose and squamulose.

Due to the critical role that lichens play in ecosystems, it is critical to understand host preferences while studying lichen ecology [6] [17] [35] [38] [46]. Furthermore, understanding lichen host specificity may be beneficial when contemplating their diversity and conservation [6] [25]. Despite several publications on lichen relationships were done in other countries [6] [25] and in Guyana's tropical forest areas of Guyana [5] [6] [11] [15] [24] [57] [58] [59] [60], there appears to be a paucity of information on lichens, particularly in coastal environments in Guyana.

Lichens are crucial in the environmental monitoring of various circumstances affecting natural resources. For example, in 2010, Fenn *et al*. used lichens as a rich resource for research and assessments of air pollution, and their ability to accumulate metals that makes them crucial for minerology [46]. The composition of the lichen community can be used to estimate environmental pollution levels because many distinct lichen species exhibit varying tolerances to air pollution [1] [22] [26] [60]. Additionally, it can be used to infer other environmental aspects similar to the effects of old-growth vegetation existing in forests due to the presence or lack of species [39] [54]. Epiphytic lichens, which grow on the surface of plants, are frequently employed as bio-indicators of environmental quality [6] and can also be used to detect environmental disturbances [6]. However, the lichen data required for environmental impact assessment and conservation studies in coastal ecosystems in Guyana is fairly restricted.

The main objective of this study was to investigate the host plant specificity of lichens in coastal agroecosystems at No. 63 Benab, Berbice, Guyana. The key research question that was addressed was whether there was lichen-host plant specificity on citrus plants at No. 63 Benab, Berbice, Guyana.

Given the current paucity of information on lichens in coastal areas of Guyana, the results of this study will add to the body of knowledge that currently exists while also benefiting not only Guyana but the world at large. It will provide information about lichens present on tropical crop plants. Information from this research will aid the Government of Guyana as well as other managing entities to make accurate plans with regards to environmental management and conservation and draw assessments of the species diversity as it concerns lichens in coastal ecosystems.

2. Material and method

2.1. Study Site

This research was carried out at No. 63 Benab, which is located on Berbice's East Coast. No. 63 Benab in Region 6 is in East Berbice Corentyne, with coordinates of -57.1487° or 57°8'55.3 W and 5.9838° or 5°59'1.6 N.

2.2. Sampling and Data Collection

The field work for this research was completed during May-September, 2022 and the data was collected from the 2000-meter square (2000 m^2) sampling plots established at both sites. Study sites of 50 m × 40 m plots were established within each of the sampling plots at their respective sites.

Undamaged free-standing trees with girths equal to or higher than 50 cm were selected at random and measured at a height of 2 m above ground, were chosen for this experiment [3] [5] [6] [52].

Quadrats made of twine measuring 50 cm x 100 cm were employed in the sample technique to survey the lichens. Each quadrat was placed to the north, south, east, and west of the tree and was lifted three feet (ft) above the ground [5] [6] [30]. Sampling was carried out within the authorized quadrats, as well as on the soil and any rocks found within the quadrat's square. Because of differences between individual trees, the very bottom of the tree's trunk was avoided [5] [6] [35].

A lichen survey datasheet prepared for this field investigation was used to record all lichen species and their frequencies inside each 50 cm × 100 cm quadrat. The cover of each target lichen species was computed to the nearest cm^2 and then expressed as a percentage of the studied trunk area [5] [6] [35].

2.3. Identification of Lichens

To identify the lichen specimens, on-site morphological observations of the thalli and apothecia of the lichen specimens were taken using a magnifying lens. Wherever possible, identification was done to the genus and species level. Identification was done using the *Mosses and Lichens a popular guide to the identification and study of our commoner mosses and lichens, their uses, and methods of preserving* by Nina L. Marshall (1919), *Forestry Commission Handbook 4: Lichen in Southern Woodlands* by Broad (1989), *A Reference Notebook: Identifying Mixed Hardwood Forest Lichens* prepared by Irwin M. Brodo and Brian Craig (2001), *Collector's Handy Book: Algae, Fungi, Diatoms, Lichens, Desmids and Mosses* by Johann Nave (n. d.). The identification process also included the use of the following dichotomous keys and identifying pamphlets: *Lichens Two Lives* by Todd Wesley (2005), *Field oriented keys to the Florida lichens* by Rosentreter *et al*. (2015), *Heathland Lichens* by Brian Eversham (2015) and *Lichen Identification Guide* (2015).

Spot tests were carried out by scraping the cortex of the lichen sample with a scalpel to expose the medulla and then adding the reagent using a pipette to evaluate the color change under a microscope [30]. If any lichens could not be identified during the field trip, a sample was collected and taken to the laboratory for identification. Following identification, all data collected was tabulated on the lichen data sheet used in the field study.

2.4. Data Analysis

The collected data from the study was statistically analyzed using R software version 4.2.2 (R-Studio) and Microsoft Excel. To compare the research data, charts, tables, and graphs were created with R version 4.2.2 (R-Studio) and Microsoft Excel.

3. Results and Discussion

This study focused on lichen - host plant specificity of lichens at two study locations at No. 63 Benab, Berbice. A total of forty (40) hosts trees were sampled to collect lichen specimens. During this investigation, fifty-two thousand three hundred eleven (52,311) lichens from fifteen (15) families, twenty-three (23) genera, and thirty (30) species were collected from two (2) sites (Table 1).

Table 1 Species frequency distribution over each site sampled

Family	Species	Site # 1	Site # 2	Total at the two Sites
Parmeliaceae	*Parmelia sulcata*	65	0	65
	Flavoparmelia soredians	681	125	806
	Flavoparmelia caperta	1697	528	2225
	Melanohalea exasperatula	440	0	440
	Hypotrachyna laevigata	181	119	300
	Usena barbata	52	0	52
	Parmelia tiliacea	107	0	107
Caliciaceae	*Dirinaria applanata*	3247	4209	7456
Chrysotrichaceae	*Chrysothrix candelaris*	1575	76	1651
Teloschistaceae	*Xanthoria parietina*	261	45	306
Lecanoraceae	*Lecanora chlarotera*	583	848	1431
	Lecanora muralis	5095	3761	8856
	Lecanora conizaeoide	5366	5705	11071
Arthoniaceae	*Cryptothecia striata*	26	0	26
	Arthonia cinnabarina	557	0	557
	Arthonia purinata	92	0	92
	Arthonia radiata	983	963	1946
Candelariaceae	*Candelaria concolor*	1489	1085	2574
	Candelariella reflexa	1287	282	1569
Stereocaulaceae	*Lepraria lobificans*	2018	1067	3085
Graphidaceae	*Graphina anguina*	492	185	677
	Graphis elegans	798	72	870
Monoblastiaceae	*Anisomeridium biforme*	489	92	581
Phlyctidaceae	*Pertusaria albescens*	1201	380	1581
	Pertusaria amara	254	0	254
Collemataceae	*Collema furfuraceum*	1013	27	1040
	Lathagrium cristatum	180	0	180
Cladoniaceae	*Gymnoderma lineare*	113	0	113
Lichinaceae	*Lichina pygmaea*	1599	0	1599
Ramalinaceae	*Bacidia laurocerasi*	379	422	801

TOTAL	32320	19991	52311

Crustose lichens were the most abundant (46%) across both sites, while crustose-leprose lichens (7%), and fruticose lichens (7%), were the least abundant. Thirty-nine percent (39%) of the lichens identified were foliose (Figure 1). The crustose lichens from the family Lecanoraceae were the most prominent with *Lecanora conizaeoide* recorded the most individuals (11071), followed by *Lecanora muralis* (8856). These two species accounted for a total of 19927 individuals that were recorded in this study which is about 38% of the overall 52311 individual lichens. The most foliose lichens were recorded in the families Caliciaceae, Lichinaceae and Candelariaceae. The family Stereocaulaceae accounted for the most crustose-leprose lichens recorded. Most fruticose lichens were recorded from the family Cladoniaceae.

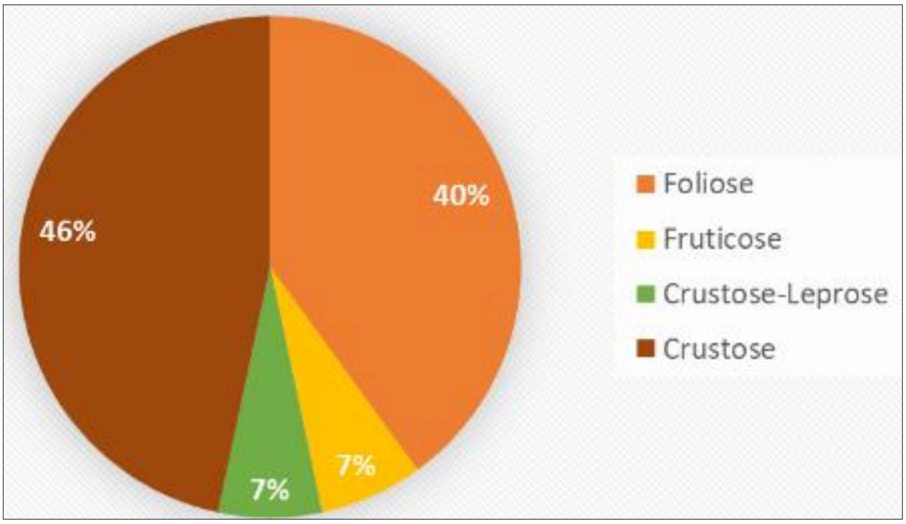

Figure 1 Lichen distribution based on their thallus type

Table 2 Number and species of trees sampled, number of lichens species present at site and observed anthropogenic influence at site

Study Site	# of trees sampled	Species of trees sampled	# of lichen species identified at site	Anthropogenic influence observed at site
#1	20	*Mangifera indica*, *Artocarpus camansi*, *Citrus aurantiifolia*, *Citrus reticulata*, *Citrus sinensis*, *Citrus limon*, *Psidium guajava*, *Annona muricata*, *Azadirachta indica*, *Melicoccus bijugales, Cocos nucifera*.	30	Yes
#2	20	*Cocos nucifera*, *Mangifera indica, Tamarindus indica*	19	Yes

Species appear to be under threat from anthropogenic activity all across the world, and lichens are among them. Cardinale *et al*., 2012 states that climate warming will pose significant difficulties to mankind and biodiversity. Furthermore, with anticipated sea-level increases that could affect coastal areas, excluding lesser-known but biologically essential species from biodiversity assessments can have ramifications for global and local conservation programs [6] [37]. The current study site is located on Guyana's coastal Plain, which has the potential to be severely damaged by the rapid sea level rise. It is critical to pay attention to lesser-known groups such as lichens, as well as the potential consequences of sea level rise for coastal areas [6] [14] [37].

A total of eighteen (18) *Cocos nucifera* (coconut) trees, eight (8) *Mangifera indica* (mango) trees, two (2) *Citrus aurantiifolia* (lime) trees, two (2) *Citrus sinensis* (orange) trees, two (2) *Citrus limon* (lemon) trees, two (2) *Psidium guajava* (guava) trees, one (1) *Artocarpus camansi* (curry-katahar) tree, one (1) *Citrus reticulata* (tangerine) tree, one

(1) *Annona muricata* (soursop) tree, one (1) *Azadirachta indica* (neem) tree, one (1) *Melicoccus bijugales* (guinep) tree and one (1) *Tamarindus indica* (tamarind) tree were sampled (Figure 2).

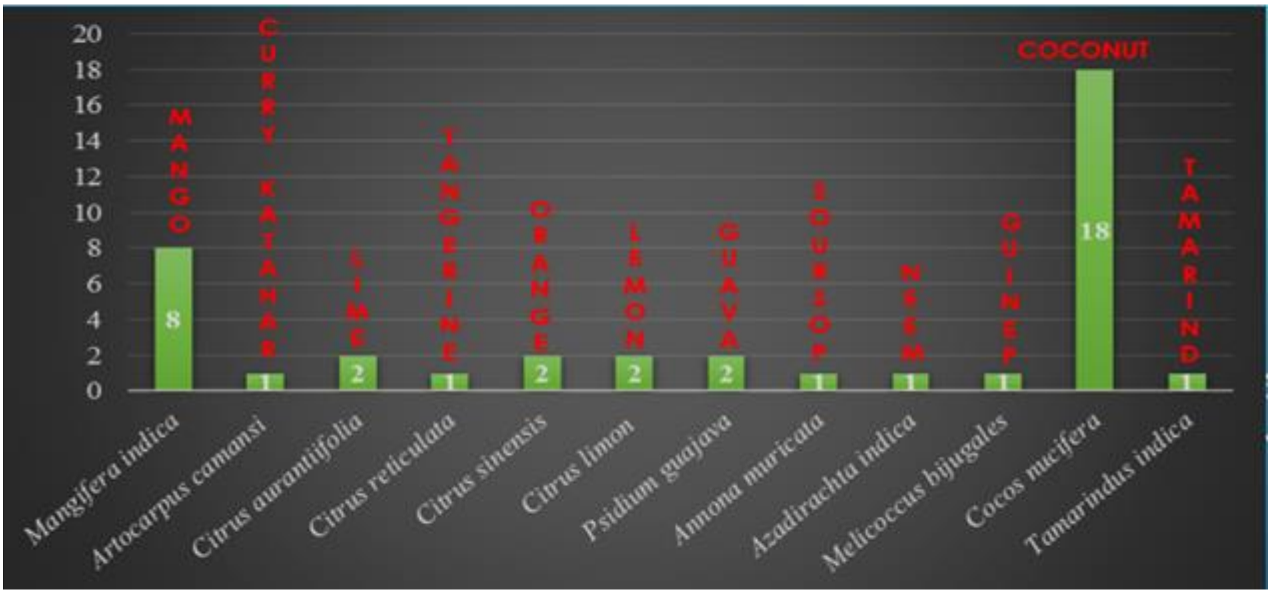

Figure 2 Distribution of trees sampled

3.1. Host Plant Specificity

Cocos nucifera showed the highest average lichens recorded in this study and accounted for 45 % of the overall trees that were sampled. Site #1 had a variety of eleven (11) trees present, whereas, Site #2 has three (3) species of plants present (Table 2). *Mangifera indica* had a higher average species recorded (20%) as compared to all the other trees except *Cocos nucifera*.

Four (4) species of lichens showed specificity towards all host trees in the study (*Flavoparmelia soredians*, *Dirinaria applanate*, *Lecanora muralis* and *Lecanora conizaeoide*). Twenty-six (26) species did not show specificity to all of the tree species sampled (Table 3).

Twelve (12) species of lichens (*Parmelia sulcata, Flavoparmelia soredians, Flavoparmelia caperta, Dirinaria applanate, Chrysothrix candelaris, Lecanora muralis, Lecanora conizaeoide, Arthonia cinnabarina, Arthonia purinata, Candelaria concolor, Lepraria lobificans, Graphis elegans*) showed host tree specificity for the four (4) species of citrus trees sampled. *Citrus sinensis* (orange) yielded all twelve (12) species of lichens that were common among the other three (3) species of citrus trees: *Citrus aurantiifolia* (lime), *Citrus limon* (lemon) and *Citrus reticulata* (tangerine) (Table 4). Three (3) species of lichens showed no specificity towards the four (4) species of citrus trees (Table 3). This number of species could be attributed to the fact that just a portion of the tree trunk was examined, as various lichen species colonize a tree at varying levels [31].

13.3 % species were found on all tree hosts: *Flavoparmelia soredians*, *Dirinaria applanate*, *Lecanora muralis* and *Lecanora conizaeoide*. *Mangifera indica* hosted 76.7 % (23 of 30 species) of all recorded species (Table 12). *Tamarindus indica* was the species to record the least number of lichen species, it hosted 26.7 % of lichens (8 of 30 species) (Table 3). This study did not evaluate factors that affect host specificity, such as pH of the bark, content of water, permeability, degree of bark shading, and the appearance of tree sap [13]. Since various lichen species are found inhabiting different levels of a tree trunk, the fact that only a portion of the tree trunk was examined may account for the low number of species [31]. Investigating such factors in subsequent studies in Guyana's coastal ecosystems could shed insight on host plant-lichen specificity and possibly provide an explanation for any observed patterns.

Table 3 Specificity of Lichens towards the twelve (12) recorded tree species

Lichen Species	*Cocos nucifera*	*Mangifera indica*	*Citrus aurantiifolia*	*Citrus sinensis*	*Citrus limon*	*Psidium guajava*	*Artocarpus camansi*	*Citrus reticulata*	*Annona muricata*	*Azadirachta indica*	*Melicoccus bijugales*	*Tamarindus indica*
Parmelia sulcata			✓	✓	✓	✓		✓				
Flavoparmelia soredians	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flavoparmelia caperta	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Melanohalea exasperatula	✓	✓										
Hypotrachyna laevigata	✓	✓										
Usena barbata		✓										
Parmelia tiliacea							✓			✓		
Dirinaria applanata	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chrysothrix candelaris	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Xanthoria parietina	✓						✓		✓		✓	
Lecanora chlarotera	✓	✓					✓		✓			
Lecanora muralis	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lecanora conizaeoide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cryptothecia striata		✓					✓					
Arthonia cinnabarina				✓		✓	✓	✓	✓		✓	

Arthonia purinata				✓		✓		✓	✓			
Arthonia radiata	✓	✓		✓					✓		✓	✓
Candelaria concolor	✓	✓		✓			✓					
Candelariella reflexa	✓	✓									✓	
Lepraria lobificans	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Graphina anguina	✓	✓	✓				✓		✓		✓	
Graphis elegans	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Anisomeridium biforme	✓	✓									✓	✓
Pertusaria albescens	✓						✓		✓	✓	✓	
Pertusaria amara		✓								✓	✓	
Collema furfuraceum	✓	✓										
Lathagrium cristatum		✓										
Gymnoderma lineare		✓										
Lichina pygmaea		✓										
Bacidia laurocerasi	✓					✓	✓		✓			✓

Table 4 Specificity of lichens towards four (4) citrus trees sampled during the study

Lichen Species	***Citrus aurantiifolia***	***Citrus sinensis***	***Citrus limon***	***Citrus reticulata***
Parmelia sulcata	✓	✓	✓	✓
Flavoparmelia soredians	✓	✓	✓	✓
Flavoparmelia caperta	✓	✓	✓	✓
Dirinaria applanata	✓	✓	✓	✓
Chrysothrix candelaris	✓	✓	✓	✓
Lecanora muralis	✓	✓	✓	✓
Lecanora conizaeoide	✓	✓	✓	✓
Arthonia cinnabarina	✓	✓	✓	✓
Arthonia purinata	✓	✓	✓	✓
Candelaria concolor	✓	✓	✓	✓
Lepraria lobificans	✓	✓	✓	✓
Graphis elegans	✓	✓	✓	✓

4. Conclusion

A higher number of crustose lichens as compared to foliose, fruticose and squamulose were recorded in this study. Host plant specificity was observed for twelve (12) species of host trees sampled in this research. Host specificity was recorded for four (4) species of recorded lichens: *Flavoparmelia soredians, Dirinaria applanate, Lecanora muralis* and *Lecanora conizaeoide*. Host plant specificity was further observed for the four (4) species of citrus host trees present. Host specificity was recorded for twelve (12) species of recorded lichens: *Parmelia sulcate, Flavoparmelia soredians, Flavoparmelia caperta, Dirinaria applanate, Chrysothrix candelaris, Lecanora muralis, Lecanora conizaeoide, Arthonia cinnabarina, Arthonia purinata, Candelaria concolor, Lepraria lobificans* and *Graphis elegans*.

More research is needed to explore various areas of the tree to see whether there is a variation in lichen diversity based on the part of the host plant. Future research should examine environmental parameters such as temperature, moisture, air quality, water quality, and salinity to determine if any of these factors influence lichen host-plant specificity in a given location. In terms of host specificity, future research should examine bark qualities that are known to influence lichen appearances to see whether there is a link between lichens and tree hosts.

Lichens are strong bio-indicators of ecological health, therefore studies on measuring and monitoring ecosystem and environmental health, particularly coastal ecosystems, can use lichens. It will be critical to assess the lichen species in different locations of Guyana as part of conservation efforts. This will aid in conservation decisions by alerting conservationists and the government on the current state of these communities because they can evaluate factors such as air quality. As a result, lichens can be employed in studies aimed at evaluating and monitoring the health of ecosystems, particularly in areas where anthropogenic activities is high.

This was a preliminary study into host-plant lichen specificity in a coastal environment of Guyana. Given that considerable development is now taking place in Guyana's coastal areas, it is important that any future study of lichens in Guyana's coastal areas must take into account the likely effects of climate change.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors hereby declare that this manuscript does not have any conflict of interest.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

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