Orthotrichum lyelli Presence in UBC Botanical Gardens and Substrate Conditions as a Determining Factor

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Abstract

The objective of this study is to determine if there is any dependency of the moss species *Orthotrichum lyelli* on any specific tree species used as substrate, specifically between the species *Malus fusca*, *Abies grandis* and *Fraxinus latifolia*. If *O. lyelli* presence is dependant on the tree species that it uses as a substrate, we expect to see significant differences between species in the number of trees with *O. lyelli* present. A line-intersect transect method was used to sample trees across all 3 species along 5 separate transects, and the presence or absence of *O. lyelli* was recorded. The number of trees of each species with *O. lyelli* present were analyzed using a one-way ANOVA, which returned a significant result of p=0.0179 (a=0.05). A post-hoc analysis was done using Tukey's multiple comparison, which showed that *Malus fusca* had a significantly higher presence of *O. lyelli* than both *Abies grandis* and *Fraxinus latifolia*, which did not differ significantly from each other. We concluded that the moisture content difference in the different tree species' preferred habitats was a determining factor in the presence or absence of this moss.

Introduction

Moss is a critical part of ecosystems that it inhabits, assisting with nutrient, carbon and water recycling, as well as creating microtopography that is vital for species of bacterium to thrive (Turetsky *et al.*, 2012). In addition, mosses and other bryophytes are cited as being indicator organisms that are extremely helpful in determining and tracking the health of ecosystems and forests (Kou *et al.*, 2020). While the importance of mosses is widely undisputed, the distribution determinants of specific species is largely lacking in the literature. Multiple studies have found a correlation between substrate pH or moisture and moss species niches (Cleavitt, 2001; Pleskova *et al.*, 2016), although specific tree species preferences for specific moss species have not been thoroughly researched. Different species of trees inhabit ecosystems with specific moisture contents, some preferring more moist habitats, such as wetlands, and some preferring drier habitats. Mosses can also thrive in habitats with a variety of moisture abundance, but drier habitats can pose a threat of damage via desiccation, which eventually can kill mosses altogether (Lee & Stewart, 1971).

Orthotrichum lyelli specifically, while a semi-popular species of moss in costal BC forests, has very little formal literature on the tree niches it inhabits, and is mostly documented by moss-sighting groups, and in few databases (E-Flora BC, 2020). While information is widely missing on the majority of bryophyte species in regard to tree species as substrate preferences, this study will focus on *O. lyelli* as it is a moderately common moss in the forests surrounding Vancouver, British Columbia. Fairly common trees in the surrounding forests were also chosen as a focus, due to the studies limits on manpower, and the research here is confined to Pacific crabapple (*Malus fusca*), Grand fir (*Abies grandis*) and Oregon ash (*Fraxinus latifolia*). This study will attempt to determine if there is dependency of *O. lyelli* on any specific tree species used as substrate. If *O. lyelli*'s growth is dependent on any specific tree species' bark that it uses as a substrate, then we can expect to see significant differences between tree species in regard to the presence of *O. lyelli*. Because of the dangers of desiccation, we expect to see *O. lyelli* present in higher amounts on Pacific crabapple and Oregon ash, as these species prefer habitats with higher moisture content in the soil and air (Parish *et al.*, 1948), and are likely to provide a habitat with lower risk of desiccation. This study provides valuable information on more specific niches of *O. lyelli* that can be used to locate it for future studies, as well as methodology that can be followed to find more specific niches for other moss species in British Columbia.

Methods and Materials

Because this study was conducted in the UBC Botanical Gardens, which place a large emphasis on preservation, off-trail sampling was not an option, and therefore 5 transects were set up along separate paths through the BC Rainforest Garden (Figure 1). Each transect was 35 meters long and sampling was done via a modified line-intercept transect method that was contained to trees within 1 meter of either side of the path.

Figure 1: Map of the UBC Botanical Garden's BC Rainforest Garden (taken from: https://botanicalgarden.ubc.ca/visit/visitor-info-maps/maps/). Transects 1-5 that were sampled are mapped in red and numbered.

If any section of the trunk at breast height was within 1 meter of the edge of the path (confirmed with measuring tape), the tree was included. Three of the most popular tree species in the BC Rainforest Garden, according to signage in the park, were chosen and sampling was restricted to Pacific crabapple (*Malus fusca*), Grand fir (*Abies grandis*) and Oregon ash (*Fraxinus latifolia*). Trees were sampled for the presence of *O. lyelli* starting at 6 inches above the ground to ensure that the moss was not using residual soil as substrate, and sampling stopped at 6 feet above the soil line in order to ensure accurate IDs, which would be difficult if the moss was too high up. Any *O. lyelli* was IDed with the help of the E-Flora BC (2020) database (Figure 2). Any amount of *O. lyelli* growing on the trees was recorded as 'present'. All sides of the tree were checked for the presence of *O. lyelli* while ensuring that area trampled off-path was minimal. Any saplings under 2 meters were excluded, as well as any dead trees. The species of the tree and the presence or absence of *O. lyelli* was recorded for analysis.

Figure 2: *O. lyelli* found on a Pacific crabapple tree in the UBC Botanical Garden's BC Rainforest Garden (Photographed by Syd Ascione, April 2021).

Results

The mean number of trees with *O. lyelli* present differed quite a bit, with Pacific crabapple having the largest mean presence. Pacific crabapple had a mean presence of 1.4, while Grand fir and Oregon ash had much smaller mean presences of 0 and 0.2, respectively (Figure 3). Pacific crabapple had the highest variation in counts of *O. lyelli* presence, with a standard deviation of ±1.14 and a 95% confidence interval of ±0.99 (Figure 3). Oregon ash has a slightly smaller standard deviation of ±0.44 and a 95% confidence interval of ±0.39, and Grand fir has a standard deviation and 95% confidence interval of ±0.00, since all 5 transects had complete absence of *O. lyelli* on Grand fir trees (Figure 3). Results were then analyzed using R stats program, and due to ANOVA returning a significant result, a post-hoc Tukey's multiple comparison test was also performed on these results.

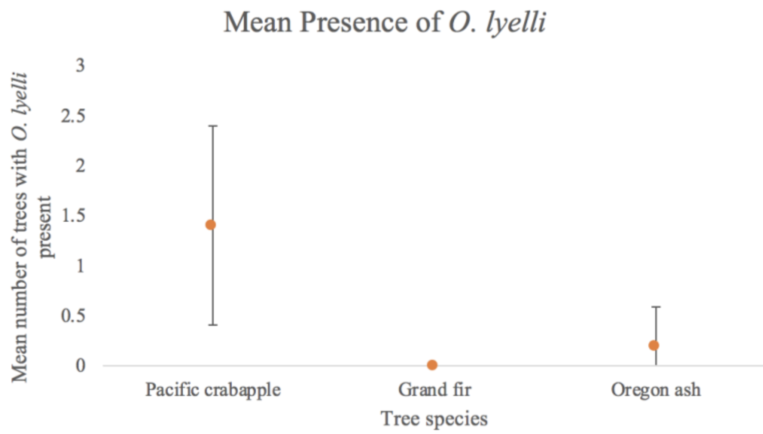

Figure 3: Mean counts of presence of *O. lyelli* across three species present in UBC Botanical Garden's UBC Rainforest Garden. Data collected in April 2021, and n=5 for all tree species. Error bars are included and represent 95% confidence intervals.

Discussion

Results were analyzed using a one-way ANOVA in R Studio. A normal variation of data was confirmed with a Brown-Forsythe test (p=0.50, a=0.05), and normal distribution of residuals was confirmed with a Q-Q plot showing a linear distribution with only one outlier. The one-way ANOVA returned a p-value = 0.0179 (a=0.05) (Table 1), and therefore we fail to accept the null hypothesis that substrate tree species has no significant effect on *O. lyelli* presence. We can then lend support to our original hypothesis that *O. lyelli* has a species-specific presence determinant of tree bark that is used as substrate. Because the one-way ANOVA returned a significant result, a post-hoc analysis was the done using Tukey's multiple comparison test to determine which species differed significantly from each other.

Table 1: One-way ANOVA results from statistical analysis comparing *O. lyelli* presence on three different tree species (N=15). Analysis performed in R Studio. (a=0.05)

	Df	**Sum Sq**	**Mean Sq**	**F value**	**P value**
Cakes	2	5.733	2.867	5.733	0.0179
Residuals	12	6.000	0.500		

Tukey's multiple comparison confirmed that while Pacific crabapple presence of *O. lyelli* differed significantly from both Grand fir and Oregon ash (p=0.022 & p=0.048, respectively), Grand Fir and Oregon ash did not differ significantly from each other (p=0.0897) (Table 2). We can then conclude that *O. lyelli* has a significantly higher presence while using Pacific crabapple as a substrate compared to Grand fir and Oregon ash.

Table 2: Tukey Multiple comparison results from a statistical analysis comparing *O. lyelli* presence on three different tree species (N=15). Analysis performed in R Studio. (a=0.05)

Species comparison	**P value**
Oregon ash – Grand fir	0.897
Pacific crabapple – Grand fir	0.022
Pacific crabapple – Oregon ash	0.048

Suspected bias in the samples across all three species potentially comes the use of the line-intersect transect method. Because the data was collected in a park where off-trail sampling was not permitted, there may be a negative bias in the counts of trees with *O. lyelli* present, as the trees closer to the path are more susceptible to edge effects as well as disturbances from visitors and weather, which can inhibit organism growth (Murcia, 1995). Importantly, while performing the Q-Q plot to test for normal distribution of residuals, a dramatic outlier was seen in the Pacific crabapple data point from Transect 1. This transect had the highest abundance of crabapple trees, as it happened to intersect a gathering of 3 individuals close together, whereas the other transects had generally fewer Pacific crabapple individuals that were more widely dispersed. This closely relates to the relatively large variations within species treatments (Figure 3), which is caused mainly by the small number of trees along each transect, which can exaggerate and largen variations between transects relative to the mean.

Importantly, Pacific crabapple trees were noted to usually be found directly next to water along all of the transects, while Grand Fir and Oregon ash were generally found farther away from the water. Although both Pacific crabapple and Oregon ash generally prefer more moist habitats (Parish *et al.*, 1948), Oregon ash were observed to exist farther from water sources compared to the Pacific crabapple in the BC Rainforest Garden. Although we predicted that *O. lyelli* presence would be dependent on the high moisture preferences of species it was using as substrate, and therefore have a significantly higher presence on both Pacific crabapple and Oregon ash, we only observed a significantly higher presence on Pacific crabapple. This is perhaps due to *O. lyelli*'s dependence not on the tree species preferred habitat, but on the habitat itself, preferring to grow in areas with higher moisture content. This can be attributed to an evolutionary adaptation to avoiding desiccation in moss species. Importantly, mosses that grow in areas with very few dry periods, like British Columbia's rainforests, are far more susceptible to desiccation, and therefore require a higher moisture content in the air and substrate (Lee & Stewart, 1971). This aligns closely with results comparing moss desiccation tolerances in mosses from habitats with a variety of moisture contents that follow this same trend (Robinson *et al.*, 2000; Schonbeck & Bewley, 1981). Therefore, while we have concluded the O. lyelli presence is indeed dependant on specific tree species, there may also be a contributing factor of the moisture content of the surroundings of individuals within that species.

Conclusion

Moisture content of moss substrates is an important factor in determining where mosses will grow in forests and is shown to have a significant impact in the presence and absence of *O. lyelli* on specific tree species. This study found that *O. lyelli* has a species-specific determinant regarding the tree bark that is used as substrate and is significantly more present on Pacific crabapples in comparison to Grand Fir and Oregon Ash. While the results of this study are significant, further investigation is required to determine, while the species of tree has proved to affect O. lyelli presence, if the associated moisture content of the preferred habitat of the tree species plays a role as well.

Acknowledgments

I would like to acknowledge the contribution of the BIOL 342 course teaching team in experimental design, methods review, and tips on carrying out the experiment. I'd also like to acknowledge the University of British Columbia for the opportunity provided to take this course.

I would like to acknowledge that this study was conducted on the traditional, ancestral, and unceded territory of the Musqueam people.

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Appendices

Appendix A: Raw data on the number of trees with *O. lyelli* present across 3 different tree species.

Transects	Pacific crabapple	Grand fir	Oregon ash
1	3	0	0
2	2	0	0
3	0	0	1
4	1	0	0
5	1	0	0
Mean	1.4	0	0.2
Std Dev	1.14017543	0	0.4472136
95% CI	0.99938946	0	0.3919928