International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Mosses of Malagos Watershed, Baguio District, Davao City; An Exploratory Study

Angel Liliana Cataytay[1], Sarah Mel Gwyneth Dequito[1], Ericka Jean Gumilan[1], Daryl Salas[2], Geonyzl Alviola[3], Erlyn DY[4]

[1]College of General Eduction Management and Sciences, Biology Program, Davao Doctors College, Inc., Gen. Malvar St., Pob. District, Davao City, 8000

[2]Faculty of Natural Science Department, College of Arts & Sciences, University of Southeastern Philippines, Bo. Obrero, Iñigo St.

[3]Faculty of Biology Program, College of General Education & Management Sciences, Davao Doctors College, Inc., Gen. Malvar St., Pob. District, Davao City, 8000

[4]Office of Chief Academic Officer, Davao Doctors College, Inc., Gen. Malvar St., Pob. District, Davao City, 8000

Doi: https://doi.org/10.55248/gengpi.5.0624.1473

ABSTRACT

Mosses are essential components of the vegetation in the Malagos Watershed, a 232-hectare protected area managed by the DENR-PAMB. Studying mosses can help us understand how they contribute to the health of the watershed by performing various ecological functions, such as stabilizing the soil and preventing erosion, filtering water and improving its quality, recycling nutrients and decomposing organic matter, storing carbon dioxide, and mitigating climate change. In addition, the Malagos Watershed has not been the subject of any moss research, and its mosses are still poorly understood. This study aimed to identify the moss species, determine the different substrates colonized by the mosses, and examine the correlation of moss species with various substrates in the watershed. Opportunistic sampling was utilized, and the collection was focused on the southeastern part of the Malagos Watershed. Field Sampling Technique were utilized in identifying moss species in Malagos watershed. Results revealed a total of 76 moss samples were collected, belonging to 25 species, 17 genera, and 11 families. The highest frequency of moss species recorded belongs to the family *Calymperaceae*, followed by *Hypnaceae* and *Sematophyllaceae*. The most common substrates for mosses were trees and rocks. The Chi-Square Test revealed that $\alpha = 0.05$, there was a significant relationship ($0.008 < 0.05$) between moss species and moss substrates. Hence, the presence of moss species is influenced by the type of substrate on which they are found. Overall, this study contributes to the knowledge of bryophyte diversity and distribution in the Malagos Watershed and supplies essential data for subsequent research in this area.

Keywords: *Malagos Watershed, species richness, moss substrate, moss colonization, moss distribution*

INTRODUCTION

Mosses are non-vascular plants belonging to the division of Bryophyta together with the liverworts and hornworts under the sub-division musci. Their lack of waterways makes them characterized as both ectohydric and poikilohydric bryophytes. Due to their dependence of water from their environment (ectohydric) and lack of water regulation mechanism (poikilohydric), their leaves are efficient in water collection by making their leaves flexible, pliable, and soft to avoid splashing in order to obtain and conserve as much water as they can (Dollery *et al*., 2022; Huttunen *et al*., 2018). A moss's foliage has an appendage attached to the gametophores stem in a lateral position consisting of cells arranged in a single layer with noticeable midrib and marginal serrations as they grow (Lin *et al.,* 2021). In contrast to vascular plants, although mosses have a root-like structure called rhizoids these roots do not function as “true roots" such as water and nutrient uptake but only function as a structural support and aid in anchoring the flora to different substrates (Neal, 2021). Similar to hornworts and liverworts, it also possesses a sporophyte in order to propagate itself and is a representative of the moss's diploid generation (Crandall-Stotler & Bartholomew- Began, 2007).

Mosses serve as an inexpensive bioindicator especially in assessing the conditions of the environment. Hence, these mosses are well known as an indicator in air quality control for their capability to gather air pollutants, especially heavy metals. They are especially utilized as a quick and cheap as well as a convenient method in assessing the status of the environment or ecosystem (Yatim & Azman, 2021). They are also significantly important in nutrient cycling, increase in soil stability, colonizing disturbed habitats, and as a helper in plant establishment. Thus, they also are responsible for controlling carbon and nitrogen cycles in the ecosystem through their capability to influence soil temperature, increase soil moisture, and difference in the density of soil organic matter (Siwach *et al*., 2021). This non-vascular plant has great capability of survival in all terrestrial ecosystems and according to Yatim and Azman (2021), this plant is incomparable to their vascular counterpart due to their abundance and wide distribution whereas some moss species can be found in extreme weather conditions.

The diversity and distribution of mosses in the Philippines are poorly documented, especially in lowland protected areas. The Malagos Watershed Reservation is a protected area in Davao City that harbors a rich biodiversity of flora and fauna, including mosses. However, no study has been done on the moss richness in this area and how it relates to the different substrates. Thus, this study was conducted to assess the diversity of the species of mosses in Malagos Watershed, Baguio District, Davao City.

METHODS

Location of the study site

The study was conducted in the Malagos Watershed Reservation, situated in Baguio District, Davao City, with coordinates of 7° 10' 56" N and 125° 24' 25" E, and an elevation ranging from 386 m to 497 m above sea level (asl). The sampling points are indicated in Figure 1.

Figure 1. Sampling Points in Malagos Watershed Reserve Map (Google Maps, 2023)

Moss Sampling, Collection, and Identification

The researchers used opportunistic sampling techniques for collecting moss specimens at the Malagos Watershed Reservation. Collecting on areas within the study site situated in zones from significant to minimal water exposure.

The treatment of collected samples from the study site to processing followed the collection and preparation techniques outlined by Shevock *et al.* (2014) and Glime (2017c). Using a scraper, an ample amount of the specimen, not exceeding 10% of the moss found on the substrate, was obtained from the plot. Immediately after acquisition, the collected moss from the sampling site was placed directly into a small, folded paper packet along with data collection, including ecological features and other attributes such as habitat conditions. Indications such as light availability, substrate, and moisture were recorded on the draft label. Samples from aquatic or wet habitats were squeezed to remove excess water, while muddy samples underwent rinsing to eliminate dirt particles and were then squeezed to remove excess water before being placed in the collecting packet. Finally, the acquired samples were transported to a small plastic container. The collected sample specimens underwent air drying, with careful attention to ensuring adequate air circulation for proper drying. Heat sources were deliberately avoided to prevent desiccation during the drying process. Sample documentation of moss species involved using Shevock's printed ecological data proforma that enables the researcher to efficiently gather and document ecological data on each collected moss sample. The documentation of samples occurred right after the acquisition of the moss specimen to ensure that each collection was recorded in detail.

The collected mosses were identified using the diagnostic characters such as the growth habit, capsule, the leaf itself including its arrangement, base, apex, margin, costa, as well as its cells using dissecting and compound microscopes. The primary method for verifying the identity of the specimens involved utilization of published works by Bartram (1939), Eddy & Buck (1991), Bill and Nancy Malcolm (2006). And Crosby *et al*. (2011). Furthermore, the collected mosses were submitted to a bryology expert for confirmation of the initial identification. After validation, a final label was generated, including details such as the moss's specific epithet, collection site, habitat description, substrate information, collection date, corresponding coordinates with altitude level, collection number, and the names of the collectors.

Statistical Tool

To determine the correlation of moss species with various substrates, the researchers employed the Chi-Square Test. This statistical method was utilized to explore the relationship between the classification of identified moss species and the type of substrate they inhabit. Additionally, the percentage of each identified moss family, as well as the percentage of moss' preferred substrate, was also determined.

RESULTS AND DISCUSSION

Species richness and composition of mosses

The study found 76 mosses, representing 25 species across 17 genera and 11 families (see Table 1). Among these, the Calymperaceae, Hypnaceae, and Sematophyllaceae families were the most species-rich, while the Thuidiaceae, Fissidentaceae, Entodontaceae, and Hypopterygiaceae families had the least species richness.

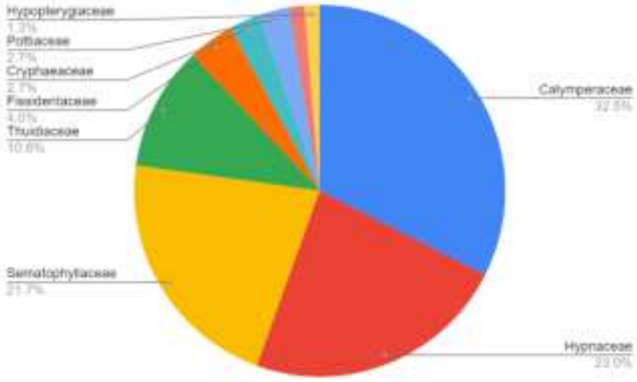

Figure 2. Distribution of moss species into different families

The data (Figure 1) reveals that a total of 76 mosses belonging to eleven different families were identified. The most abundant family was Calymperaceae, accounting for 31.6% of the total mosses found. This family is characterized by having leaves with a distinct calyptra-like structure at the apex, which covers the capsule and protects the spores (Reese & Stone, 2012; Seppelt et al., 2022). Calymperaceae is widely distributed in tropical and subtropical regions and is often found on tree trunks, rocks, and soil. Some of the common genera of this family are *Leucophanes* and *Syrrhopodon*.

Hypnaceae and Sematophyllaceae were also significant, with 22.4% and 21.1% respectively. These families are composed of primarily epiphytic mosses, which grow on the surfaces of other plants, such as branches, leaves, and bark. Sematophyllaceae is distinguished by having leaves with a single costa (midrib) and cells with papillae (projections) on both surfaces (Han & Jia, 2020). Hypnaceae is characterized by having leaves with a double costa or none at all and cells with papillae only on the upper surface (Khan *et al.,* 2020). One of the common genera of Sematophyllaceae is *Acroporium*, while one of the common genera of Hypnaceae is *Vesicularia*. The moss families Calymperaceae, Hypnaceae, and Sematophyllaceae are abundant in the Philippines because they are well-adapted to the tropical and subtropical climate of the country, which is characterized by high temperature, humidity, and rainfall (Mejia *et al*., 2020).

According to a study by Alcala *et al.* (2020), the most represented families of mosses in the Greater Sipit Subwatershed of the Mt. Makiling Forest Reserve, a protected area in Laguna, Philippines, are Calymperaceae (7 species), Fissidentaceae (5 species), and Hypnaceae (4 species). These families make up 61.5% of the total mosses found in the area. Another study by Montecillo *et al*. (2020) reported the species richness of moss flora on the montane vegetation of Mt. Apo Natural Park, a protected area in Davao, Philippines. The study identified 79 moss species belonging to 36 genera and 20 families. The most abundant families are Sematophyllaceae (15 species), Hypnaceae (8 species), and Calymperaceae (6 species). These studies suggest that the moss families Calymperaceae, Sematophyllaceae, and Hypnaceae are common and diverse in the Philippines, especially in the montane forests, where they can thrive in moist and shady habitats. Other families like Thuidiaceae, Fissidentaceae, Entodontaceae, and Hypopterygiaceae are present but in smaller proportions. Thuidiaceae makes up 10.5% of the total mosses and is characterized by having leaves with a double costa, cells with papillae on the upper surface, and capsules with a long and curved beak (Touw, 2014). Some of the common genera of this family are Thuidium, Abietinella, and Leskea. Fissidentaceae accounts for 3.9% of the total mosses and is distinguished by having leaves with a unique arrangement, where the upper and lower halves are separated by a deep fissure, giving the appearance of teeth (Bartram, 1972). The common genus of this family is *Fissidens*. Entodontaceae and Hypopterygiaceae each makeup 1.3% of the total mosses. One of the common genera of Entodontaceae is *Entodon*, while *Hypopterygium* is for Hypopterygiaceae. Moss families such as Thuidiaceae and Entodontaceae are not abundant in the Malagos Watershed because they have different ecological preferences and adaptations than the more common families like Calymperaceae, Sematophyllaceae, and Hypnaceae. These mosses grow best in moisture with increasing altitude, where they can tolerate colder conditions (Manual e*t al.,* 2015).

In general, the number of species tends to rise with elevation, usually linked to heightened humidity, diverse microclimates, and a range of available substrates. Moss communities are more significantly impacted by these factors than forest structures despite bryophytes exhibiting resilience to extreme conditions. Existing literature often connects higher altitudes with lower temperatures and more humid, cloudy climates — ecological conditions favorable for a diverse moss species. Consistent with many zoning studies involving bryophytes, the areas with the highest diversity are typically located at the highest elevations (Mejia et al., 2020). The sampling site, Malagos Watershed, has an elevation of 386 m - 497 m above sea level (asl) and can be considered a low elevated place, with a minimal gap (111 m) between the minimum and maximum elevation of the sampling site (Salvador, 2023). In addition, due to some restrictions in accessing some areas, the researchers only covered a small area to conduct sampling activities. That is why there is a limitation in the collection of samples, resulting in only 65 bryophyte samples collected, as stated above.

Classification of Mosses

From the 76 samples collected, the species with the highest frequency is Leucophanes glaucum (14), followed by Vesicularia vesicularis (9), and Pelekium sp. (6). Table 1 presents the checklist of mosses at Malagos Watershed, Baguio District, Davao City.

Table 1. Checklist of Mosses at Malagos Watershed, Baguio District, Davao City

Family	**Genus**	**Species Name**	**Frequency**
Brachytheciaceae	Brachythecium	*Brachythecium* sp. 1	1
Calymperaceae	Syrrhopodon	*Syrrhopodon* sp. 1	1
		Syrrhopodon sp. 2	1
		Syrrhopodon sp. 3	1
		Syrrhopodon sp. 4	1
	Leucophanes	*Leucophanes glaucum* (Schwägr.) Mitt.	14
	Octoblepharum	*Octoblepharum albidum* Hedw.	3
	-	-	3
Cryphaeaceae	Acrocryphaea	*Acrocryphaea concavifolia* (Griff.) A. Jaeger	2
Entodontaceae	-	-	1
Fissidentaceae	Fissidens	*Fissidens robinsonii* Broth.	1
		Fissidens sp. 1	2
Grimmiaceae	-	-	1
Hypnaceae	Ctenidium	*Ctenidium* sp. 1	2
	Vesicularia	*Vesicularia vesicularis* (Schwägr.) Broth.	9
		Vesicularia dubyana (Müll. Hal.) Broth.	1
		Vesicularia sp. 1	1
	Isopterygium	*Isopterygium sp*	2
	-	-	2
Hypopterygiaceae	Hypopterygium	*Hypopterygium vriesei* Bosch & Sande Lac.	1
Pottiaceae	Hyophila	*Hyophila involuta* (Hook.) A. Jaeger	2
Sematophyllaceae	Mastopoma	*Mastopoma robinsonii* (Broth.) E.B. Bartram	1
	Acroporium	*Acroporium diminutum* (Brid.) M. Fleisch.	1
		Acroporium sp. 1	1
	Chiostomum	*Chiostomum* sp.1	1
	Meiothecium	*Meiothecium* sp.1	1
	-	-	11
Thuidiaceae	Pelekium	*Pelekium velatum* Mitt.	1
		Pelekium sp. 1	6
	Thuidium	*Thuidium plumulosum* (Dozy & Molk.) Dozy & Molk	1

The moss families listed in Table 1 belong to different families within the class Bryopsida. Bryopsida is the largest and most diverse class of mosses, containing about 95% of all moss species. It is characterized by having peristomes, which are tooth-like structures that surround the opening of the capsule and help regulate the release of spores (Glime, 2017a). The eleven (11) moss families identified include Hypnaceae, Hypopterygiaceae, Calymperaceae, Sematophyllaceae, Fissidentaceae, Thuidiaceae, Brachytheciaceae, Grimmiaceae, Pottiaceae, Cryphaeaceae and Entodontaceae that are prominent within the Malagos Watershed Reservation area are widely distributed in the tropical regions of the world.

The family Brachytheciaceae boasts a cosmopolitan distribution of its species, thriving in diverse regions such as the arctic, boreal, temperate, subtropical, and tropical zones. These mosses attach to rocks, barks, and even soils (Ignatov, 2020). Remarkably, they can flourish at altitudes as low as 7550 feet (Montana et al., 2023). Within the Brachytheciaceae family, the Genus Brachythecium is commonly found growing on rocky substrates, with certain species within this genus specifically thriving on damp or moist rocks in stream beds.

According to Bartram (1972), mosses of Calymperaceae are usually found attached in tufts on trees which are habit exhibited by identified species *L. glaucum*, *O. albidum* as well as *Syrrhophodon* sp. 1. Furthermore, this moss family are resilient on prolonged dry period and are also found in lower elevations (Shevock et al., 2017).

The moss family Cryphaeaceae is a family of mosses that contains about ten genera and 150 species. *Acrocryphaea concavifolia* is one of the species in this family, and it is a small moss that grows on tree trunks and branches. *A. concavifolia* has a wide distribution, ranging from tropical Africa, Asia, Australia, and the Pacific islands (Reese, 1999). It is found in the Philippines, where it is one of the common epiphytic mosses in lowland forests. Specifically, it can be found in areas of lower elevation, where the climate is warm and moist, and where there are more suitable substrates, such as trees and shrubs (National Museum of the Philippines, 2021).

The family Entodontaceae exhibits a widespread distribution globally, extending to the Pacific Islands. As a pleurocarpous family, it is renowned for thriving on tree trunks and inhabiting rocky substrates, particularly in tropical areas (Fife, 2014).

Families like the acrocarpous family Fissidentaceae exhibit a wide distribution in regions characterized by high temperatures and humidity, with their species predominantly limited to lowland areas. As altitude increases, the number of species decreases (Suzuki et al., 2018). This family, consisting of the single genus Fissidens, holds the distinction of being the largest genus in the world of moss genera, showcasing complex diversity with a multitude of species (Kwon, 2021).

Among the collected moss species within Genus Fissidens, such as Fissidens robinsonii and Fissidens sp. 1, they are commonly found anchoring near moist aquatic environments. According to Budke et al. (2022), many taxa within this moss family inhabit aquatic habitats, preferring moist and shady environments while avoiding direct exposure to sunlight, as observed in the case of *Fissidens* sp. 1 and *Fissidens robinsonii*. These mosses grow on substrates along rivers, such as trees and rocks. As noted by Mazhar-Ul-Islam (2020), this family thrives across various environments, from lowland wet or moist forests to high mountainous regions.

The family Grimmiaceae showcases a global distribution in contrast to other families that typically thrive in dry and exposed environments, colonizing rocks, stones, and occasionally trees. It frequently forms dark green to black moss cushions (Hastings & Ochyra, 2019). Notably, certain species within the Grimmiaceae family are also found in lowland areas (Maier et al., 2017).

The Family Hypnaceae is considered one of the largest and most diversified families of pleurocarpous mosses with a cosmopolitan distribution. Whereas it comprises 1,000 species and 60 genera throughout the globe (Khan et al., 2020).

According to Bartram (1972), the genus *Ctenidium* tends to attach itself to trees as well as to rocks. Meanwhile, members of the genus *Vesicularia* are commonly used as “aquarium moss" for decoration. In the wild, Vesicularia species are found along streams. The predominant commonality of the two identified species, *V. vesicularis* and *V. dubyana* is their access to moist - wet environments. They are commonly placed along stream banks. According to Ho et al. (2015), these mosses are usually situated on wet grounds along stream banks or settling on wet forest floors.

The family Hypopterygiaceae is commonly encountered in regions with high humidity, predominantly distributed along humid forests in temperate to tropical areas worldwide. In contrast to the aforementioned larger moss families, Hypopterygiaceae, with its relatively low number of species, also exhibits a low number of classified genera. These pleurocarpous mosses typically display a creeping, inverted, and slanted growth form, mainly occupying the wet surfaces of rocks in fully shaded areas. One notable characteristic of this moss family is exemplified by *Hypopterygium vriesei*, which is often found on rock walls situated in shaded areas along streams. Additionally, it tends to thrive along stream banks, ensuring continuous access to water (Meng et al., 2020; Kruijer, 2002).

The moss family Pottiaceae is one of the largest and most diverse families of mosses, with about 1500 species distributed worldwide. *Hyophila involuta* is a member of this family, and it is a small moss that grows on wet rocks, often in streams. *H. involuta* has a nearly cosmopolitan distribution but is more common in tropical and subtropical regions (Zander & Allen, 2019). It is found in the Philippines, where it is one of the few mosses that can tolerate high temperatures and frequent drying and wetting cycles. Specifically, it can be found in areas of lower elevation, where the climate is warmer and more humid, and where there are more suitable habitats, such as streams, rivers, and wet cliffs (National Museum of the Philippines, 2021).

The family Sematophyllaceae is predominantly distributed worldwide, with a thriving presence in tropical to temperate regions (Schofield, 2020). As noted by Han and Jia (2020), it stands out as one of the most diverse moss families within pleurocarpous moss, commonly flourishing in areas where water availability ranges from moist to wet. These mosses are typically found on substrates such as trees and logs (Bartram, 1972). The observed behavior of *Acroporium* sp. 1 and *Acroporium diminutum* aligns with the family's characteristics. On the other hand, *Mastopoma robinsonii* is often found thriving in soil or rock substrates, particularly in shady and moist areas (Selina Wamucii, 2023).

With seven (7) genera identified in regions like Tropical Asia and the Western Pacific, the family Thuidiaceae comprises pleurocarpous mosses widely distributed worldwide, predominantly inhabiting lowland forests (Touw, 2001; Ellis et al., 2019; Pephu, 2014). Often characterized as moss in thin mats, species in this family are found on various substrates such as rocks, logs, dead wood, and even sandstone. According to Bartram (1972), species within the genus *Pelekium*, specifically *P. velatum* and *Thuidium plumulosum* are, commonly thriving on logs or dead wood.

Substrates Colonized by the Mosses

The most common substrate for mosses in the Malagos Watershed is tree trunk, which accounts for 40% of the total area. This suggests that mosses prefer to grow on woody surfaces that provide support, moisture, and nutrients. Tree trunks may also offer protection from direct sunlight, wind, and herbivores. Additionally, the tree bark's grooves and crevices enable the moss spores to be established (Forest Preserve District Willcounty, 2020). The second most common substrate is rock, which covers 20% of the area. These rock surfaces were found near the stream and are constantly supplied with enough water. Rock crevices, which occupy 4.4% of the area, also provide favorable microhabitats for mosses, as they can trap water, soil, and organic matter (Encyclopaedia Britannica, 2023). The third most common substrate is tree base, which occupies 11.1% of the area. Tree bases are similar to tree trunks, but they are more sheltered than on tree trunks with a relatively high humidity as well as reduced light intensity. Some mosses may grow on tree bases due to spore dispersal from tree trunks or soil (Sales et al., 2016). The other substrates are less common, and they include tree leaves (2.2%), tree-fallen/dead/rotten branches (11.1%), soil humus (8.9%), soil clay (1.1%), and tree branch (1.1%). These substrates vary in physical and chemical properties, such as texture, pH, moisture, and nutrient content. Mosses grow on different substrates due to their high adaptability to different environmental conditions that allow them to thrive not only in wet habitats but also in dry ones as well (Asher, 2023).

Table 2. Substrate Preference of Moss species in Malagos Watershed

MOSS FAMILY	MOSS SPECIES	Substrate					
		Tree			Rock		Soil
		Trunk	Base	Fallen/Dead/ Rotten Branch	Top/ Wall	Crevice	Humus
Brachytheciaceae	*Brachythecium* sp. 1				✓		
Calymperaceae	*Leucophanes glaucum* (Schwägr.) Mitt.	✓					
	Octoblepharum albidum Hedw.	✓		✓			✓
	Syrrhopodon sp. 1				✓		
	Syrrhopodon sp. 2	✓					
	Syrrhopodon sp. 3				✓		
	Syrrhopodon sp. 4		✓				
Cryphaeaceae	*Acrocryphaea concavifolia* (Griff.) A. Jaeger			✓			
Fissidentaceae	*Fissidens robinsonii* Broth.				✓		
	Fissidens sp. 1				✓		
Hypnaceae	*Ctenidium* sp. 1	✓			✓		
	Isopterygium sp	✓		✓			
	Vesicularia dubyana (Müll. Hal.) Broth.						✓
	Vesicularia sp. 1					✓	
	Vesicularia vesicularis (Schwägr.) Broth.	✓	✓	✓	✓		✓
Hypopterygiaceae	*Hypopterygium vriesei* Bosch & Sande Lac.				✓		
Pottiaceae	*Hyophila involuta* (Hook.) A. Jaeger					✓	
Sematophyllaceae	*Acroporium diminutum* (Brid.) M. Fleisch.		✓				
	Acroporium sp. 1			✓			
	Chiostomum sp. 1	✓					
	Mastopoma robinsonii (Broth.) E.B. Bartram						✓
	Meiothecium sp. 1				✓		
Thuidiaceae	*Pelekium* sp. 1	✓	✓	✓	✓		
	Pelekium velatum Mitt.	✓					
	Thuidium plumulosum (Dozy & Molk.)	✓					

The results presented in Table 2 suggest that moss species exhibit varying degrees of substrate specificity, ranging from very narrow to very broad. Moss species *Hypopterygium vriesi* Bosch & Sande Lac. of the family Hypopterygiaceae demonstrates a narrow preference for habitat, specifically favoring rocks in the tropical forest of Malagos Watershed Reservation. This indicates that *H. vriesei* is a highly specialized and rare moss species, contrasting with the more general substrate preference of Vesicularia vesicularis (Schwägr.) Broth of the family Hypnaceae, which thrives in various habitats, including trees, rocks, and soils.

Additionally, certain species, such as *Hyophila involuta* of the family Pottiaceae and *Fissidens robinsonii* Broth. and *Fissidens* sp. 1 of the family Fissidentaceae exhibit a distinct preference for rock substrates. This suggests that these moss families, particularly the mentioned species,

have adapted to the specific conditions of their preferred substrates, including factors like moisture, temperature, light, and nutrients. Furthermore, some moss species from the families Calymperaceae and Hypnaceae prefer moist and shaded substrates, such as the base of a tree, fallen/dead/rotten branches, tree leaves, and the top/wall of rocks. This implies that these families, along with their respective species, share similarities in their ecological requirements, potentially leading to competition or coexistence.

These results can be explained by various factors influencing the distribution and diversity of mosses, including elevation, climate, substrate chemistry, and human disturbance (Turetsky et al., 2012). The tropical climate of the Malagos Watershed, with distinct wet and dry seasons, influences the availability and quality of substrates for mosses. Mosses, being dependent on water, may exhibit different growth patterns during these seasons, with some species having adaptations to cope with drought. Substrate preferences, whether for water retention or quick drying, can influence the advantage of certain moss species during specific seasons.

Using Chi-square test, the following hypotheses were formulated:

- Null hypothesis (H_0): There is no significant relationship between moss species and moss substrates.
- Alternate hypothesis (H_1): There is a significant relationship between moss species and moss substrates.

Since $0.008 < 0.05$, reject H_0. Thus, there is enough evidence at $\alpha = 0.05$ that there is a significant relationship between moss species and moss substrates. It means that the presence of moss species is influenced by the type of substrate on which they are found.

CONCLUSION

This study revealed that the area has a significant number of mosses for lower elevations, with a total of 76 samples belonging to 25 species, 17 genera, and 11 families. Mosses of the Malagos Watershed relatively have a lower species richness compared to areas with higher elevations. Thus, elevation and climatic conditions indeed significantly influence the diversity of mosses, particularly in areas where non-vascular plants struggle to survive. Additionally, the history of human exploitation in the region posed a threat, potentially impacting the abundance of moss species. However, ongoing protection of the watershed might improve the status of mosses through time. In terms of substrate preference, the study showed a significant correlation between moss substrates and moss species. Overall, this study contributes to the knowledge of bryophyte diversity and distribution in the Malagos Watershed and supplies essential data for subsequent research in this area.

ACKNOWLEDGMENT

The authors are grateful to the Department of Environment and Natural Resources-Protected Area Management Board (DENR-PAMB) for granting the permission to conduct the study. Also, to the guards of the Philippine Eagle Foundation (PEF) and the guides of the DCWD for ensuring the safety and security during the fieldwork. Finally, to the Department of Science and Technology (DOST), for the scholars' financial assistance that enabled the researchers to pursue their academic goals.

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