Annals of
Plant Sciences
Volume 9, Issue 8 (2020) pp. 3957 - 3969
ISSN: 2287-688X
Research Article

Distribution of Bryophytes in the University of the Philippines-Diliman, Quezon City, Philippines

Ericka Jane A. Angeles*, Monaliza B. Magat, Ryan Sherwin D. Jalandoni
Institute of Biology, University of the Philippines-Diliman, Philippines.

Abstract: This study was conducted to document the bryophyte species composition and the effects of different environmental factors at the University of the Philippines-Diliman, a campus in an urban area. A total of 11 species of bryophytes were identified which includes nine species of mosses and two species of liverworts. Among the species observed, *Hyophila involuta* (Hook.) A. Jaeger and *Taxithelium instratum* (Brid.) Broth. were found to be widely distributed across sites. On the other hand, *Meiothecium microcarpum, Cyathodium foetidissimum* Schiffn. and *Vesicularia montagnei* (Bel.) were rarely found. Species composition is relatively small compared to the previous surveys conducted in high altitude and moist environments. It was suggested that aside from habitats, other factors such as current disturbance events and the presence of specific tree species may contribute more to the bryophyte species composition in the University of the Philippines-Diliman campus.

Keywords: Bryophytes; moss; liverwort; Philippines.

Introduction

Bryophytes are the nonvascular cryptogams and the second largest group of green plants following angiosperms (Deora and Deora, 2017). Currently, this group of plants includes approximately 24,000 species worldwide having three separate divisions, namely: Bryophyta (mosses) with 15,000 species, Marchantiophyta (liverworts) with 8,500 species, and Anthocerophyta (hornworts) with approximately 300 species (Azuelo *et al.,* 2011).

Bryophytes are shade and moist-loving plants and are said to successfully exploit many habitats because they are rarely in competition with higher plants (Deora and Deora, 2017). These plants tend to be more abundant in humid climates and their diversity often corresponds with habitat diversity (Hallingback and Hodgetts, 2000). These plants have a significant role in the function of the ecosystem as the first colonizers of different varieties of habitats (Alam *et al.,* 2011). Some are effective soil binders which prepare areas suitable for other plants through their ability to trap moisture and windblown organic debris (Deora and Deora, 2017). Furthermore, bryophytes also play a significant role as biological indicators of air pollution since these groups are vulnerable to the changes in their environment and thus, they can serve as a model system for researches concerning climate change. Their potential to be used as indicators of air quality arises from their ability to accumulate heavy metals by atmospheric deposition. Few species play a 'keystone' role in the cycling of minerals, regulation of microclimate in the forest canopy, and in providing food and habitat for different invertebrates (Shevock *et al.,* 2014; Sabovljevic and Sabovljevic, 2009). Moreover, they keep the dynamics of understory vegetation, the stability of soil structure as well as the interception and retention of water (Shaw and Goffinet, 2000; Azuelo *et al.,* 2010).

As a tropical country, the Philippines provides environments conducive to the growth of bryo-

*Corresponding Author:
Ericka Jane A. Angeles
E-mail: eaangeles1@up.edu.ph

phytes. But, to date, still very few scientists and researchers have taken interest in the study of bryological species and vegetation (del Rosario, 1979), especially the dearth of information regarding the relationship of these plants with the unique environmental conditions prevailing at various ecological zones of the country (Hipol *et al.,* 2007). Most of the bryophyte studies in the Philippines were conducted in protected areas, parks or landscapes such as in Mt. Matumtum protected area in South Cotabato, Philippines (Azuelo *et al.,* 2016); Mt. Kitanglad, Bukidnon (Azuelo *et al.,* 2010), in Island Garden City of Samal, Philippines (Carreon *et al.,* 2016) and in Kalikasan Park, Albay, Philippines (Salvador-Membreve *et al.,* 2019). More specifically, there are only a few studies of bryophytes focusing on the urban species (Sabovljevic and Sabovljevic, 2009). Since mosses are unlikely to be artificially introduced in an ecosystem, this makes them the perfect species to be used as indicators of the true stature of the environment (Hipol *et al.,* 2007). Studying bryophyte species in urban areas is essential because of the unique habitats urbanized areas provide, and the species take roles in improving air quality (Sabovljevic and Sabovljevic, 2009). Thus, this study aims to document the bryophyte species present in an urban landscape at the University of Philippines - Diliman campus and to identify the environmental factors affecting their occurrence. Moreover, this study seeks to find out if the campus, which is situated in an urban area can provide various habitats that can support different species of bryophytes.

Materials and Methods

Study site

The study was conducted within the University of the Philippines - Diliman (14°39'14.0"N 121° 04'06.6"E), with a total area of 493 hectares within an urban area in Quezon City, Metro Manila, Philippines (Ong *et al.,* 1999).

The study site (**Figure 1**) was divided into five land use zones: (1) academic zone, (2) protected area, (3) central campus core, (4) parks and open spaces, and (5) residential and mixed-use zones (Espina and Espina, 2013).

Field sampling

All plots used in the study have dimensions of 10m X 10m and were placed randomly within the sampling sites. Bryophyte specimens were collected from patches found within the area of the plot. Habitat type, air temperature, and relative humidity of the sampling area were recorded for each plot. The samples collected were categorized into the following: (1) epiphytic, (2) rupestrian and chasmophytic, (3) reophilic, and (4) terrestrian. Reophilic species are those which thrive in areas with flowing water or near water. Rupestrian and chasmophytic species thrive in either wet, shaded, sunny and dry concrete, mortar, tiles, bricks, limestone, acidic rocks, and walls. Terrestrian species grow in sunny, dry, humid, and nitrified soil. Epiphytic bryophytes are those found on the bases or trunks of trees (Sabovljevic and Sabovljevic, 2009).

Collection and identification of bryophytes

Freshly collected samples were obtained from February to April 2019 at 7:00 to 10:00 AM. The samples were collected carefully with the aid of a sharp-edged blade. Samples were placed into a folder paper pocket with field label data including the ecological features of the area. The samples were then placed in a plastic container during transport and further collection of other samples in the field. Two to three duplicates were collected, avoiding the removal of the 10% of the population from the substrate as indicated by Shevock *et al.,* (2014).

In situ species differentiation of specimens was done by scanning the morphological characteristics such as leaf arrangement, sporophyte characteristics, and stem structure using a hand lens. Initial species identification was done based on the key of Bartram (1939) and was sent to a tropical bryophyte expert for verification. Morphological characteristics were viewed under a dissecting microscope for a more detailed examination. Various relevant literatures were consulted for final identification work including Tan *et al.,* (2000), Ramsay *et al.,* (2002), and Duckkett and Ligrone (2006).

Data processing

Canonical Correspondence Analysis (CCA) was performed to determine the relationship between the species incidence (presence or absence) data and the environmental variables (Carchini *et al.,* 2007). To incorporate the habitat types where the bryophytes were found in the CCA ordination, categorical data were transformed by creating four variables, namely: (1) epiphytic, (2) rupestrian and chasmophytic, (3) reophilic, and (4) terrestrian. For every sample plot, a value of 1 was given to the habitat type where a species was found and 0 to the rest (Greenacre, 2013; Ramette, 2007). The values of these variables were plotted as environmental arrows to generate a plot with an eigenvalue of at least 0.4 and thus, a CCA plot fit for interpretation (terBraak and Verdonschot, 1995). This was carried out using Paleontological Statistics Software Ver. 3.24 developed by Hammer *et al.,* (2001).

Results

There were 11 bryophyte species found across different land-use zones in UP Diliman. These species were comprised of nine species of mosses and two species of liverworts (**Table 1** and **Figure 4**). Among the land use zones, the academic zone has the highest number of species, while the protected area zone has the lowest number of bryophyte species (see **Table 2**).

Environmental variables

The habitat types of the bryophyte species were listed in **Table 3** and the distribution of bryophytes sampled according to their habitat was illustrated in **Figure 2**. The most common species found were epiphytic, rupestrian and chasmophytic bryophytes and the most common substrates recorded were tree trunks, concrete, and rocks.

The CCA triplot (**Figure 3**) demonstrates the relationships that occur between the environmental variables recorded and the corresponding correlation with species occurrence. The orientation of an environmental arrow from the origin indicates the direction of the maximum increase of values of a variable. Acute angles formed between environmental arrows indicate a positive correlation, while obtuse angles indicate a negative correlation. The species centroids (dots) are plotted near the sites where they are most likely to be found (terBraak and Verdonschot, 1995).

The arrow for the variable Epiphytic indicates the direction of the increasing number of sampled epiphytic bryophytes across sites. Thus, epiphytic bryophytes are uncommon in academic land use areas and in UP Biology arboretum (protected area) but are more common at the central campus core, residential areas, and open spaces. Likewise, the direction of the arrow for the variable Rupestrian indicates the increasing number of sampled rupestrian and chasmophytic bryophytes across sites. Thus, rupestrian and chasmophytic bryophytes are less common in open spaces and residential areas while they are more common in the central campus core, academic land use areas, and protected area.

Based on the acute angle between the arrows for Epiphytic and AT (air temperature), it can be inferred that the epiphytic bryophytes are more common in areas with higher temperatures, namely: open spaces, residential areas, and the central campus core. In addition, the acute angles between the arrows for RH (relative humidity), Reophilic, and Rupestrian demonstrate that reophilic, rupestrian and chasmophytic bryophytes are more common in areas with lower temperature and hence, high relative humidity.

On the other hand, most sites found in the academic land use zones and arboretum were different from the other sites based on axis 1 separation since these have lower air temperatures, higher relative humidity, and most of the bryophytes sampled from these sites thrive in rupestrian and chasmophytic habitats. Nonetheless, this could have been confounded by sampling dates, and consequently the shift from cool dry season to the hot dry season. Moreover, only rupestrian species were collected in the UP Institute of Biology arboretum.

The average air temperature and average relative humidity in each sampling area were summarized in **Table 4**. The number of epiphytic, rupestrian and chasmophytic, reophilic, and terrestrian habitats occupied by bryophytes in each land use was listed in **Table 5**.

Table 1. List of Bryophyte species found at the University of the Philippines-Diliman campus.

Species	Family	Defining characteristics
Entodontopsis anceps (Bosch & Sande Lac.) W.R. Buck & Ireland	Stereophyllaceae	Costa single and extending ¾ of the leaf. Leaf cells are rhomboidal in apex. Seta is long and capsules are erect.
Trachyphyllum inflexum (Harv.) A. Gepp	Pterigynandraceae	Leaves are cordate, cells rhomboidal, slightly papillate at the apex, quadrate at the base, basal angle cells transversely elongated, costa small, and bifurcated.
Calymperes tenerum Müll. Hal.	Calymperaceae	Leaf blade is composed of 1 or rarely 2 layers of similar cells. Inner basal cells are large and empty and are sharply differentiated from the small chlorophyllose blade.
Lejeunea flava (Sw.) Nees	Lejeuneaceae	Thallus small, leaf bilobed with distinct lobules. Under leaves are either bifid or bilobed.
Meiothecium microcarpum	Sematophyllceae	Leaves with unipapillose cells (Tan *et al.,* 2000). Alar cells are mostly few, large, and inflated.
Taxithelium instratum (Brid.) Broth.	Stereophyllaceae	Cells at the apex of leaves are short rhomboid and papillose; mid-lamellar cells are thin-walled and narrowly rhomboid (Ramsay *et al.,* 2002)
Hyophila involuta (Hook.) A. Jaeger	Pottiaceae	Inner basal cells are not conspicuously differentiated, leaves with inner longitudinal lamellae. Upper leaf cells are papillose, rounded and obscure.

Entodon cernuus (Müll. Hal.) A. Jaeger	Entodontaceae	Alar cells are numerous and colorless. Capsules are cylindrical and erect.
Cyathodium foetidissimum Schiffn.	Cyathodiaceae	The thallus is 4-5mm wide and 25 mm long. It is luminous light green in color. Wings are often interrupted forming rounded lobes and sometimes extending to the midrib (Duckkett and Ligrone, 2006).
Vesicularia montagnei (Bel.) Broth.	Hypnaceae	Leaf cells are firm narrow, elongate, and not complanate. These are small mosses that are often regularly pinnate.
Fissidens flaccidus Mitt.	Fissidentaceae	Leaves are equitant and distichous, with dorsal blade and single costa.

Table 2. Presence of bryophyte species across land-use zones in UP Diliman.

Species	Academic Zone	Protected Area	Open Space	Campus Core	Residential Area
Calymperes tenerum	-	-	+	+	+
Cyathodium foetidissimum	+	-	-	+	-
Entodon cernuus	+	+	+	-	-
Entodontopsis anceps	+	-	+	+	+
Fissidens flaccidus	+	-	+	-	-
Hyophila involuta	+	+	+	+	+
Lejeunea flava	+	-	+	+	+
Meiothecium microcarpum	-	-	-	+	-
Taxithelium instratum	+	-	+	+	+
Trachyphyllum inflexum	+	-	+	+	+
Vesicularia montagnei	+	-	-	-	-
Total number of species	9	2	8	8	6

Table 3. Bryophyte species in the University of the Philippines – Diliman and their habitats.

Species	Type of Habitat	Substrate
Calymperes tenerum	rupestrian and chasmophytic	rock, concrete
	epiphytic	tree trunk
Cyathodium foetidissimum	rupestrian and chasmophytic	rock
Entodon cernuus	rupestrian and chasmophytic	rock
	reophilic	rock on stream
Entodontopsis anceps	rupestrian and chasmophytic	rock, concrete
	epiphytic	tree trunk
Hyophila involuta	epiphytic	tree trunk
	rupestrian and chasmophytic	rock, concrete
Fissidens flaccidus	rupestrian and chasmophytic	rock
Lejeunea flava	epiphytic	tree trunk
	rupestrian and chasmophytic	rock, concrete
Meiothecium microcarpum	epiphytic	tree trunk

Taxithelium instratum	epiphytic	tree trunk
	rupestrian and chasmophytic	rock, cement
	terrestrian	soil
Trachyphyllum inflexum	epiphytic	tree trunk
	rupestrian and chasmophytic	rock, cement
Vesicularia montagnei	rupestrian and chasmophytic	rock, cement

Table 4. Average air temperature and average relative humidity across the sampling sites.

Land Use Zone	Air Temp. (˚C)	Relative Humidity (%)
Academic Zone	32.3	51
Institute of Biology Arboretum (Protected Area)	30.9	55
Central Campus Core	33.2	51
Open Spaces	32.9	50
Residential Area	33.1	49

Table 5. Number of epiphytic, rupestrian and chasmophytic, reophilic, and terrestrian habitats occupied by bryophytes sampled in each land use zone in UP Diliman campus.

Land Use Zone	Epiphytic habitats	Rupestrian and Chasmophytic habitats	Reophilic habitats	Terrestrian habitats
Academic Zone	4	11	1	0
Institute of Biology Arboretum (Protected Area)	0	6	0	0
Central Campus Core	20	16	0	0
Open Spaces	34	5	0	0
Residential Area	36	5	0	1

Table 6. Number of plots where bryophyte species were found. The total number of 10m X 10m plots sampled was 42.

Species	Academic Zone	Protected Area	Open Space	Campus Core	Residential Area	Total no. of plots
Calymperes tenerum	0	0	2	4	3	9
Cyathodium foetidissimum	1	0	0	0	0	1
Entodon cernuus	1	3	0	0	0	4
Entodontopsis anceps	3	0	8	7	4	22
Fissidens flaccidus	1	0	0	1	0	2
Hyophila involuta	6	3	2	4	9	24
Lejeunea flava	1	0	7	6	8	22
Meiothecium microcarpum	0	0	1	0	0	1
Taxithelium instratum	1	0	9	5	8	23
Trachyphyllum inflexum	1	0	6	6	9	22
Vesicularia montagnei	1	0	0	0	0	1

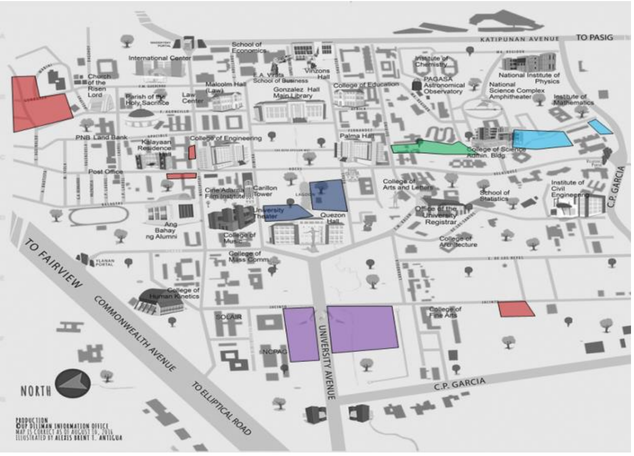

Figure 1. Sampling sites around the university campus from an illustrated map (Antigua, 2016). The sampling areas are classified into academic zones (sky blue), protected areas (green), central campus core (blue), parks and open spaces (violet), and residential and mixed-use zone (red).

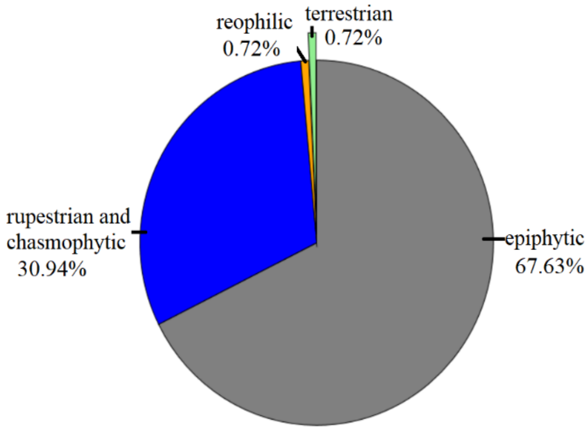

Figure 2. Percentage of bryophytes found in this study. There were 94 epiphytic bryophytes, 43 rupestrian and chasmophytic bryophytes, 1 reophilic and 1 terrestrian species.

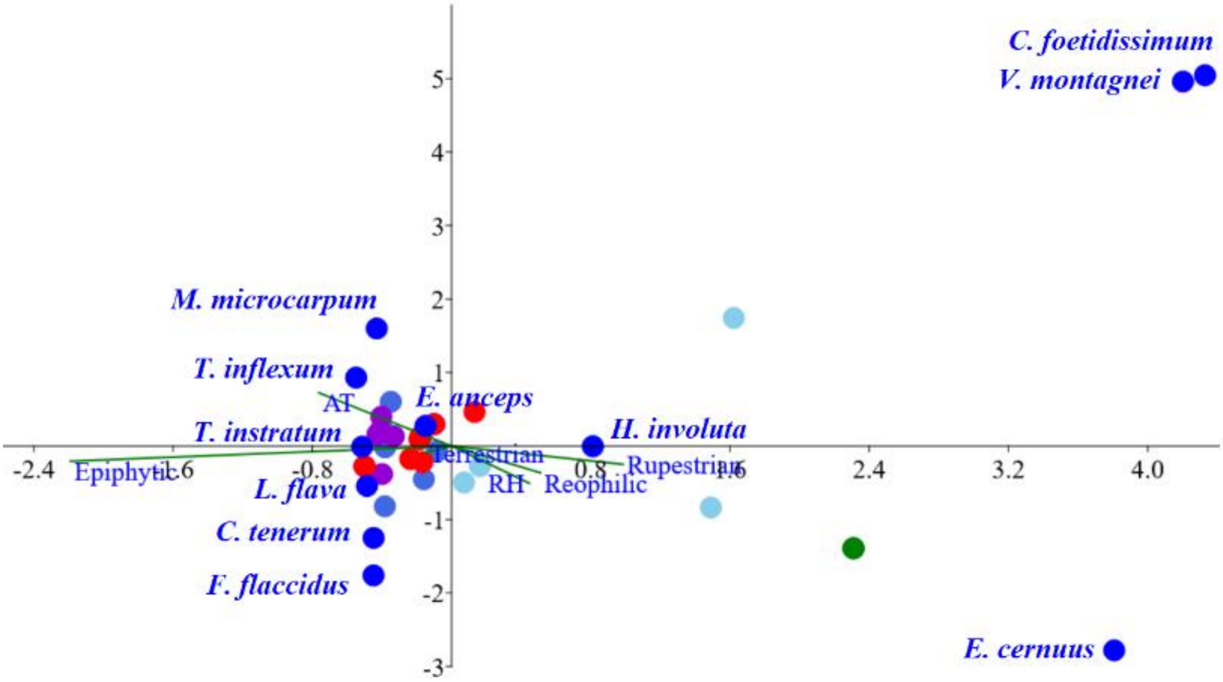

Figure 3. Canonical correspondence analysis (CCA) triplot generated based on species incidence data. Eigenvalues for Axis 1 (horizontal)= 0.49 (75.01%); Axis 2 (vertical)= 0.07 (11.26%). Dots represent the following: species (blue); academic land use (sky blue); UP Biology Arboretum - protected area (green); residential area (red); central campus core (blue); and open spaces (violet). Environmental arrows are shown in green.

Bryophyte species observations

Both *Hyophila involuta* and *Taxithelium instratum* were found to occupy most of the plots. *Taxithelium instratum* was the only species recorded to be terrestrian, while *Entodon cernuus* was the only species recorded as reophilic. As shown in **Figure 3**, the centroids of the species *Meiothecium microcarpum, Cyathodium foetodissimum, Vesicularia montagnei* and *Entodon cernuus* appeared to be isolated as these were found only in certain sites. For example, *Meiothecium microcarpum* was found only in a single plot in the open space land use zone, while *Cyathodium foetidissimum* and *Vesicularia montagnei* were found in plots within the academic land use zone only. *Entodon cernuus* was found only in UP Institute of Biology arboretum (protected area) and academic land use zones. Although it was expected for the protected area zone to contain more species and habitats, high leaf litter from the surrounding mahogany trees (*Swietenia macrophylla)* was observed and these might have impeded bryophyte establishment. The number of plots where bryophyte species were found was summarized in **Table 6**.

Discussion

Two tropical liverworts namely, *Cyathodium foetidissimum* and *Lejeunea flava* were found. The luminescent green thalli of the liverwort *Cyathodium* are usually observed growing in ditches, banks, and other deeply shaded areas. It contains 14 species that are mostly confined to the Neotropics, Paleotropics, or Asia (Duckkett and Ligrone, 2006). *Lejeunea flava*, which was also widely distributed across the sites was mainly observed at the base of tree trunks, especially of mango trees (*Mangifera indica*). These species of liverworts were found mostly in moist recesses and observed growing on barks of trees and wet logs. Similar to the liverworts, mosses were found on the surface of trees, rocks, cement, and pavements.

Hyaline cells and papillose are mostly found in mosses. These cells result when the lamina shrinks with the inward leaf rolling under unfavorable or stressful conditions. Once precipitation occurs, these cells enable an accelerated water uptake resulting in an erect leaf. In the case of *Fissidens flaccidus*, sheathing at the base of the leaves enables a reduction in the evaporative surface that forms a small reservoir between the sheathing portion and the stem (Deora and Deora, 2017). This characteristic of *Fissidens flaccidus* is speculated to be exploited by *Calymperes tenerum* as these species were found in close association with each other.

Taxithelium instratum was the only species observed to thrive in a terrestrial habitat but most of the succeeding collections were epiphytic. The site where this species was observed thriving on soil was at the residential area having numerous trees providing cover and protection. Although highly likely, other possible reasons why some were found in soils could also be due to the soil chemical properties in the location which is no longer investigated in this study.

Hyophila involuta and *Taxithelium instratum* appeared the most across the study sites whereas the rarest species were *Meiothecium microcarpum, Cyathodium foetidissimum* and *Vesicularia montagnei*, only found once in the academic zone and open spaces. The low number of species observed in the protected area may be attributed to the presence of invasive Mahogany trees on site. Aside from its thick leaf litter, Mahogany's allelopathic effects could impede the growth and survival of other plants (Mukaromah *et al*., 2016).

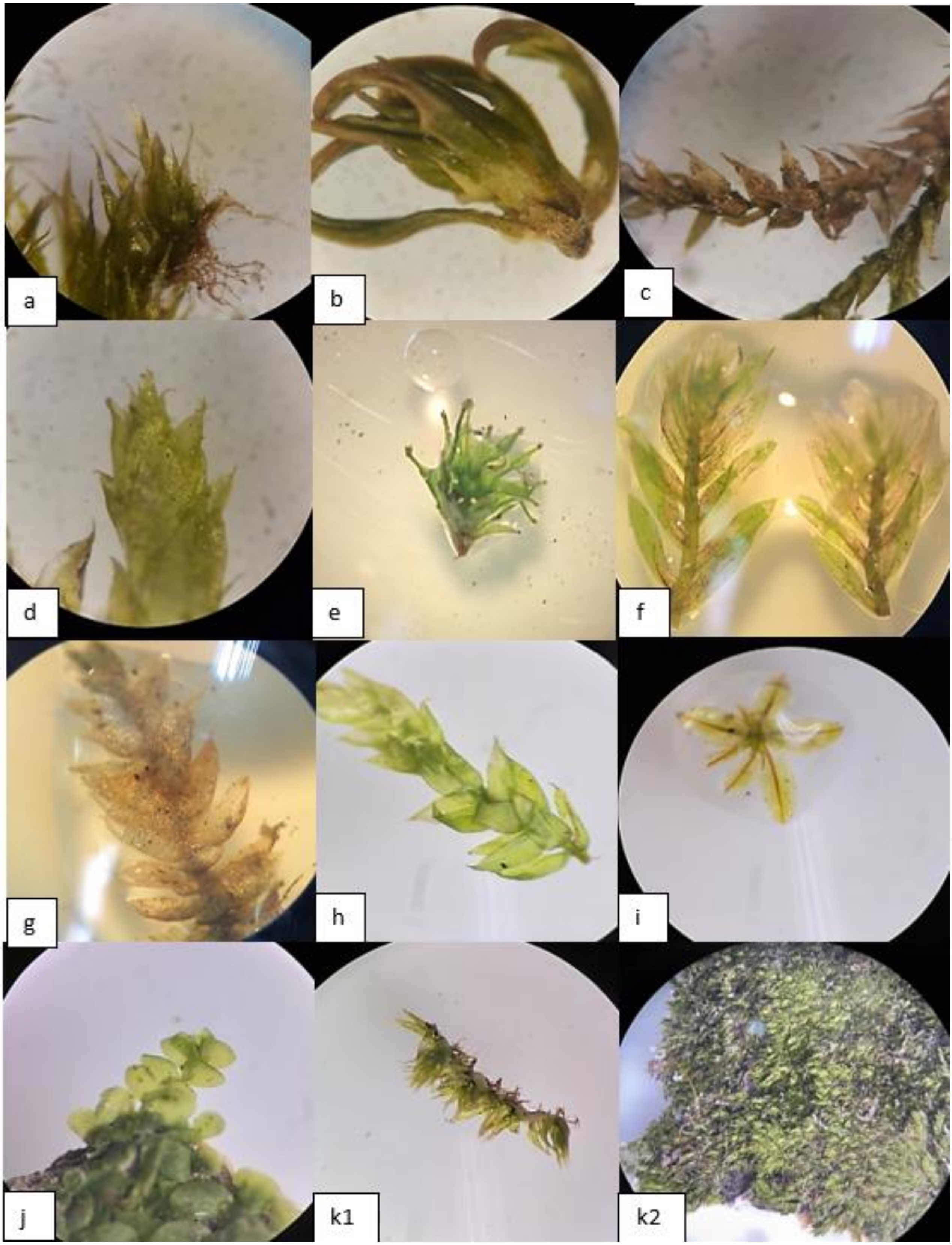

Figure 4. (a) *Entodontopsis anceps* **(b)** *Hyophila involuta* **(c)** *Trachyphyllum inflexum* **(d)** *Vesicularia montagnei* **(e)** *Calymperes tenerum* **(f)** *Fissidens flaccidus* **(g)** *Entodon cernuus* **h)** *Taxithelium instratum* **(i)** *Cyathodium foetidissimum* **(j)** *Lejeunea flava* **(k1)** *Meiothecium microcarpum* and **(k2)** intact *Meiothecium microcarpum.*

As found in this study, the University of the Philippines - Diliman campus, lying within an urban area was revealed to have only a few habitat types that could support a relatively small number of bryophyte species. The bryophyte species sampled in the area were mostly epiphytic and cement-thriving, which were found to endure high-temperature conditions. Like other species occurring within the campus, the bryophytes found in this study might be always subjected to man-made environmental changes and be tolerant to such disturbance events (Ong *et al.,* 1999). However, *Lejeunea flava* is listed as a near-threatened species (Gonzalez, 2019) while *Hyophila involuta* is considered a vulnerable species (Cogni *et al.,* 2019). The remaining collected species are not yet assessed for their status.

Compared with other studies, a survey at the University of Mindanao, Matina Campus in Davao City by Medina and Carreon (2018) identified five species of bryophytes. Three of them are liverworts under the family Lejeuneaceae which are *Lejeunea catanduana*, *Lejeunea bornensis* and *Lejeunea elliptica;* two were mosses under the family Bryaceae, which are *Bryum apiculatum* and another species needing further identification. As the researchers concluded, the small number of species documented inside the UM Matina Campus indicated that the existing environment is no longer suitable for endemic species which were previously sighted in the area. On the other hand, Salvador-Membreve and colleagues (2019) had a total of 8 species of bryophytes collected in Kalikasan Park, a man-made forest located behind the Bicol University main campus. Similar to our study, most of these species were mosses and only two species were liverworts. The following genera found in our study, namely: *Entodon sp.*, *Fissidens sp.*, and *Calymperes sp.,* were also present in the Kalikasan Park. The University of Mindanao in Matina, the University of the Philippines - Diliman, and the Kalikasan Park are in urban areas, therefore, these sites are vulnerable to many forms of environmental disturbances including infrastructure developments (Salvador-Membreve *et al.,* 2019). It is also expected that a small list of bryophytes will be obtained as compared to surveys conducted in high altitude and moist areas like Mt. Kitanglad and Mt. Kalatungan (Lubos, 2009) in Mindanao and Mt. Pulag in Luzon (Hipol *et al.,* 2007). Since this study represents the baseline data of species composition in UP Diliman, it is difficult to identify the original composition of species in the area.

All of the observed species of mosses were expected to be seen at the study sites. As from expert independent surveys conducted by Dr. Virgilio Linis, five additional species of mosses should have been included and found in this study. Mosses such as *Splachnobryum indicum, Barbula indica, Gemmabryum coronatum, Marchantia polymorpha,* and *Riccia beyrichiana* were the species not observed by the researchers (V. Linis, personal communication, April 27, 2019). The reason behind not finding these mosses could be due to the substrates within the UP campus as well as the sampling conditions. Active projects of construction and building parks within the campus could also add to the occurrence of disturbance. As in the case of *Splachnobryum indicum,* it is usually found on well shaded and very moist compacted soils. Considering the sampling season from the last week of February to the first week of April, high temperatures were expected as the study was conducted during the dry season. More species of bryophytes could be spotted if the sample collections were conducted during the wet season (June - December), given other appropriate conditions for each species of bryophytes.

Conclusion

UP Diliman campus provides only a few types of habitat – mostly epiphytic, rupestrian and chasmophytic in high air temperature conditions. Among the bryophytes, *Hyophila involuta* and *Taxithelium instratum* were found to be widely distributed within the campus. Species composition is relatively small compared with bryophyte surveys conducted on high altitude and moist environments. Nonetheless, bryophyte studies in urban areas are still lacking. This study provided the baseline data of species composition of bryophytes in the UP Diliman Campus and seeks to aid in its proper monitoring. This study also provided an insight into the evaluation of bryophyte species in an urban setting. As the less explored group of plants, discoveries regarding other factors affecting the assembly of these species such as surrounding vegetation, disturbance events such as ongoing infrastructure developments and warming climate would be necessary.

Acknowledgment

The specimen identification was made with the help of Dr. Virgilio C. Linis from De La Salle University, Manila, Philippines. Field sampling equipment was provided by the Terrestrial Research in Ecology and Evolution (TREE) Laboratory at the UP Diliman Institute of Biology. The Aquatic Biology Research Laboratory (ABRL) of the institute also provided the microscopes needed for the morphological examination of the samples collected.

References

1. Alam, A., P.K. Verma, G. Asthana, and S. Yadav. "Moss Flora of Plani Hills (Tamil Nadu) India- A checklist". *Archive for Bryology.* 112 (2011): 1-7. Online.
2. Antigua, A.B.T. "UP Diliman Campus Map." Image. University of the Philippines Diliman (2016). Online.
3. Azuelo, A.G., L.G. Sariana, and M.P. Pabualan. "Diversity and Ecological Status of Bryophytes in Mt. Kitanglad, Bukidnon, Philippines". *Asian Journal of Biodiversity.* 1.1 (2010): 49-71. Online.
4. Azuelo, A.G., L.G. Sariana, and M.P. Pabualan. "Some Medicinal Bryophytes: their Ethnobotanical Uses and Morphology". *Asian Journal of Biodiversity*. 2.92 (2011): 49-80. Online.
5. Azuelo A., A. Manual, C.D. Obemio, E. Oconer, R. Gubalane and G. Lobredo. "Bryophyte flora of Mt. Matutum protected landscape, South Cotabato, Philippines". *Journal of Biodiversity and Environmental Sciences* 9(2016): 1-12. Online.
6. Azuelo A., L. Sariana and M. Pabualan. "Diversity and ecological status of bryophytes in Mt. Kitanglad, Bukidnon". *Asian Journal of Biodiversity* 1 (2010): 49-71. Online.
7. Bartram, E.B. "Mosses of the Philippines". *Philippine Journal of Science* 68 (1939): 1-423. Online.
8. Carchini, G., V. Della Bella, A.G. Solimini and M. Bazzanti. "Relationships between the presence of odonate species and environmental characteristics in lowland ponds of central Italy". *Annales de Limnologie - International Journal of Limnology.* 43.2 (2007): 81–87. Online.
9. Carreon, H., N. Morales, A. Cabras and M.N. Medina. "Preliminary list of bryophytes in Tagbaobo, Kaputian, Island Garden City of Samal, Philippines". *University of Mindanao International Multidisciplinary Research Journal*. 1 (2016): 152-157. Online.
10. Cogoni, A., P. Campisi, C. Garcia, N. Hodgetts, J. Kucera, F. Lara and M. Lüth. "*Hyophila involuta*. *The IUCN Red List of Threatened Species* 2019: e.T87561597A8777-1973". International Union for Conservation of Nature's Red List of Threatened Species. (2019). Online.
11. Deora, V. and G.S. Deora. "Morphotaxonomical studies on some mosses of Indian Thar desert". *Annals of Plant Sciences* 6. 12 (2017): 1893-1897. Online.

12. del Rosario, R.M. "Moss flora of the national botanic garden, Quezon province Philippines. Agricultural Research Center", National Institute of Science and Technology, Manila (1979): 129-130. Online.

13. Domingo, W.J.M., M.N.D. Medina and E.P. Leaño. "Annotated list of bryophytes and lichens from Mainit Hot Spring Protected Landscape, Nabunturan, Compostela Valley, Mindanao, Philippines". *International Journal of Current Research in Bioscience and Plant Biology,* 2.10 (2012): 110-119. Online.

14. Duckkett, J.G. and R. Ligrone. "*Cyathodium* Kunze (Cyathodiaceae: Marchantiales), a tropical liverwort genus and family new to Europe, in Southern Italy". *Journal of Bryology* 28(2006): 88–96. Online.

15. Espina, M.A.A. and C.S.P. Espina. "Principles of a Sustainable UP Diliman Campus". UP Diliman Office of the Vice Chancellor for Research and Development. (2013). Online.

16. Greenacre, M. "Fuzzy coding in constrained ordinations". *Ecology.* 94.2 (2013): 280-286. Online.

17. González Mancebo, J. "*Lejeunea flava*. *The IUCN Red List of Threatened Species* 2019: e.T8754-3392A87714237". International Union for Conservation of Nature's Red List of Threatened Species. (2019). Online.

18. Hallingbäck, T., and N. Hodgetts (compilers). "Mosses, Liverworts, and Hornworts. Status Survey and Conservation Action Plan for Bryophytes". IUCN/SSC Bryophyte Specialist Group, United Kingdom. (2000). Online.

19. Hammer, Ø., D.A.T. Harper and P.D. Ryan. "PAST: Paleontological statistics software package for education and data analysis". *Palaeontologia Electronica* 4.1 (2001): 9pp. Online.

20. Hipol, R.M., D. Tolentino, B. Fernando and N.M. Cadiz. "Life Strategies of Mosses in Mt. Pulag, Benguet Province, Philippines". *Philippine Journal of Science* 136.1 (2007): 11-18. Online.

21. Linis, V.C. "Biogeographical Notes on the Moss Floras of Bicol Peninsula in Luzon and Catan - duanes Islands, the Philippines". *Philippine Journal of Science* 142 (2011) : 119-133. Online.

22. Lubos, L.C. "Species Richness, Distribution, and Status of Mosses in Selected Mountains in Mindanao, Philippines". *Asian Journal of Biodiversity* 103 (2009): 72-90. Online.

23. Medina, M.N.D., and H.G. Carreon. "Lichens and Bryophytes in the University of Mindanao, Matina Campus, Davao City, Philippines". *University of Mindanao International Multidisciplinary Research Journal* 3.1 (2018): 1-7. Online.

24. Mukaromah, A.S., Y.A. Purwestri and Y. Fujii. "Determination of Allelopathic Potential in Mahogany (*Swietenia macrophylla* King) Leaf Litter Using Sandwich Method". *Indonesian Journal of Biotechnology* 21. 2 (2016): 93-101. Online.

25. Ong, P.S., M.D.G. Pedregosa and M.G. de Guia. "Wildlife Inventory of the University of the Philippines (UP) Diliman and Ateneo de Manila University Campus Diliman, Quezon City, Luzon, Philippines". *Science Diliman* 11.1 (1999): 6-20. Online.

26. Ramette, A. "Multivariate analyses in microbial ecology", *FEMS Microbiology Ecology* 62.2 (2007): 142-160. Online.

27. Ramsay, H.P., W.B. Shofield and B.C. Tan. "The genus Taxithelium (Bryopsida, Sematophyllaceae) in Australia". *Australian Systematic Botany* 15 (2002): 583-596. Online.

28. Sabovljević, M. and A. Sabovljević. "Biodiversity within urban areas: A case study on bryophytes of the city of Cologne (NRW, Germany)" *Plant Biosystems* 143.3 (2009): 473-481. Online.

29. Salvador-Membreve, D.M., E.N. Baňares and J.J.G Guerrero. "Bryophyte Flora of Kalikasan Park, Albay, Philippines". *Journal of Biodiversity and Environmental Sciences* 15.2 (2019): 1-6. Online.

30. Shaw, A.J., and B. Goffinet. "Bryophyte Biology". Cambridge: Cambridge University Press. (2000). Online.

31. Shevock, J.R., I.A.F. Lambio and B.C. Tan. "Collection and Preparation Techniques of Bryophyte Specimens in Biodiversity Inventories." California Academy of Sciences, USA. (2014): 395-405. Online.

32. Tan, B.C., L. Lubos and U. Schwarz. "New and Biogeographically Noteworthy Records of Philippine Mosses from Mindanao Island". *Tropical Bryology* 18(2000): 27-37. Online.

33. ter Braak, C.J.F. and P.F.M. Verdonschot. "Canonical correspondence analysis and related multivariate methods in aquatic ecology". *Aquatic Sciences.* 57.3 (1995): 255-289. Online.

Cite this article as:

Ericka Jane A. Angeles, Monaliza B. Magat, Ryan Sherwin D. Jalandoni. Distribution of Bryophytes in the University of the Philippines-Diliman, Quezon City, Philippines. *Annals of Plant Sciences.* 9.8 (2020) pp. 3957-3969.

http://dx.doi.org/10.21746/aps.2020.9.8.1

Subject Editor : Prof. N. Yasodamma, Department of Botany, Sri Venkateswara University, Tirupati, Andhra Pradesh, India.

Source of support: Nil; **Conflict of interest:** Nil.