

Diversity of mosses in Mt. Makiling forest reserve, Philippines

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Abstract. Alcala AA. 2019. Diversity of mosses in Mt. Makiling forest reserve, Philippines. *Biodiversitas* 20: 1729-1734. One of the essential parts of ecosystem diversity are the mosses. The study aimed to compare the diversity of mosses along altitudinal gradients in the Makiling and Sipit trails of the Mt. Makiling Forest Reserve (MMFR). Sampling plots were established every 100 m. asl elevation. Moss specimens were collected inside a 100m² plot and re-examined under dissecting and compound microscope. A total of 77 moss species were identified in all plots established in which 43 and 48 species from Makiling and Sipit trail, respectively. Low species richness in lower elevation can be explained by higher degree of disturbances compared in higher elevation. Furthermore, species richness, diversity and abundance increase with increasing elevation. In contrast, higher temperature decreases species richness, abundance and diversity. In general, moss diversity is positively affected by increasing elevation in both trails. This is also supported by correlation analysis on moss species composition for the two sampling sites while sudden decreases in diversity in sampling plots located at 600 m. asl and 900 m. asl (Sipit Trail) and 800 m. asl and 1,000 m. asl (Makiling Trail) could simply be due to the presence of canopy gaps or disturbances in the site. Results implied that mosses used as indicators for impacts of climate change due to their sensitivity to environmental changes.

Keywords: Abundance, bryophyte, Mt. Makiling Forest reserve, species richness, moss diversity

INTRODUCTION

Bryophyte is a collective term for small, simple, spore-bearing, non-vascular plants characterized as having a dominant gametophyte generation and unbranched diploid sporophytes that remain attached to the maternal gametophyte throughout their life span; thus, are characterized to have a heteromorphic life cycle (Shaw and Beer 1999). Under bryophytes, mosses (Bryophyta) is one of the significant components of ecosystem biodiversity and an important part of species diversity (Grytnes et al. 2006; Steel et al. 2004). It also plays an important role in the forest vegetation by giving a good soil structure, soil stability and water retention (Bates 2000). A scientific base has been identified to justify the uses of the bryophytes such as some liverworts and moss extracts have antibacterial, antifungal, antiviral activity, detoxicant and antitumor (Wu 2007). Recently, there have been 150 ethnobotanical species of bryophytes reported to be more interesting both because of their relative rarity, lowly and small growth plants and for the insights they can provide about the relation between people and the medicinal value it can give (Haris 2008).

In the Philippines, the moss checklist of the Philippines (Tan and Iwatsuki 1991) enumerates 700 species, under 228 genera belonging to 55 families, including a number of mosses from Mt. Makiling. In Mindanao Island, a total of 187 genera and 314 species of mosses, 50 of which are known only from this island. The rest are found also in Luzon and the islands of the Visayas. Among the 50 species of Philippine mosses known from Mindanao, 4%

are widespread in the tropics, 60% are Malesian taxa, 21% have an Australasian link, 10% have a Bornean link, and only 6% have a continental Asiatic connection. Clearly, the moss flora of Mindanao has a strong southern and Australasian influence compared to other large islands in the country (Tan 1998).

In the case of Mt. Makiling, it was reported that the mountain caters 155 species (Tan and Iwatsuki 1991). Botanically, the mountain is extensively studied in terms of vascular flora as exemplified by the works of Pancho (1983), Pancho and Gruezo (2006), Gruezo (2000), Lambio and Buot (2011), Abraham et al. (2010).

Mt. Makiling Forest Reserve (MMFR) is a favorable locality for the study as it is regarded as one of the best known biological areas and one of the 18 centers for plant diversity in the Philippines. In view of this, there is a need to conduct moss bryoflora in MMFR. The study aimed to provide the baseline/update of moss species list in two (2) forest trails of Mt. Makiling and to compare species diversity between Makiling Trail and Sipit Trail.

MATERIALS AND METHODS

Study area

Mt. Makiling is located at 13.87 N 120.9 E and 14.28 N 121.5 E (Figure 1). Mt. Makiling Forest Reserve (MMFR), Philippines is subdivided into four sub-watersheds: Molawin-Dampalit, Cambantoc, Tigbi, and the Greater Sipit. The study was conducted in two sites: Greater Sipit and Molawin-Dampalit subwatershed from 300-1000 m. asl.

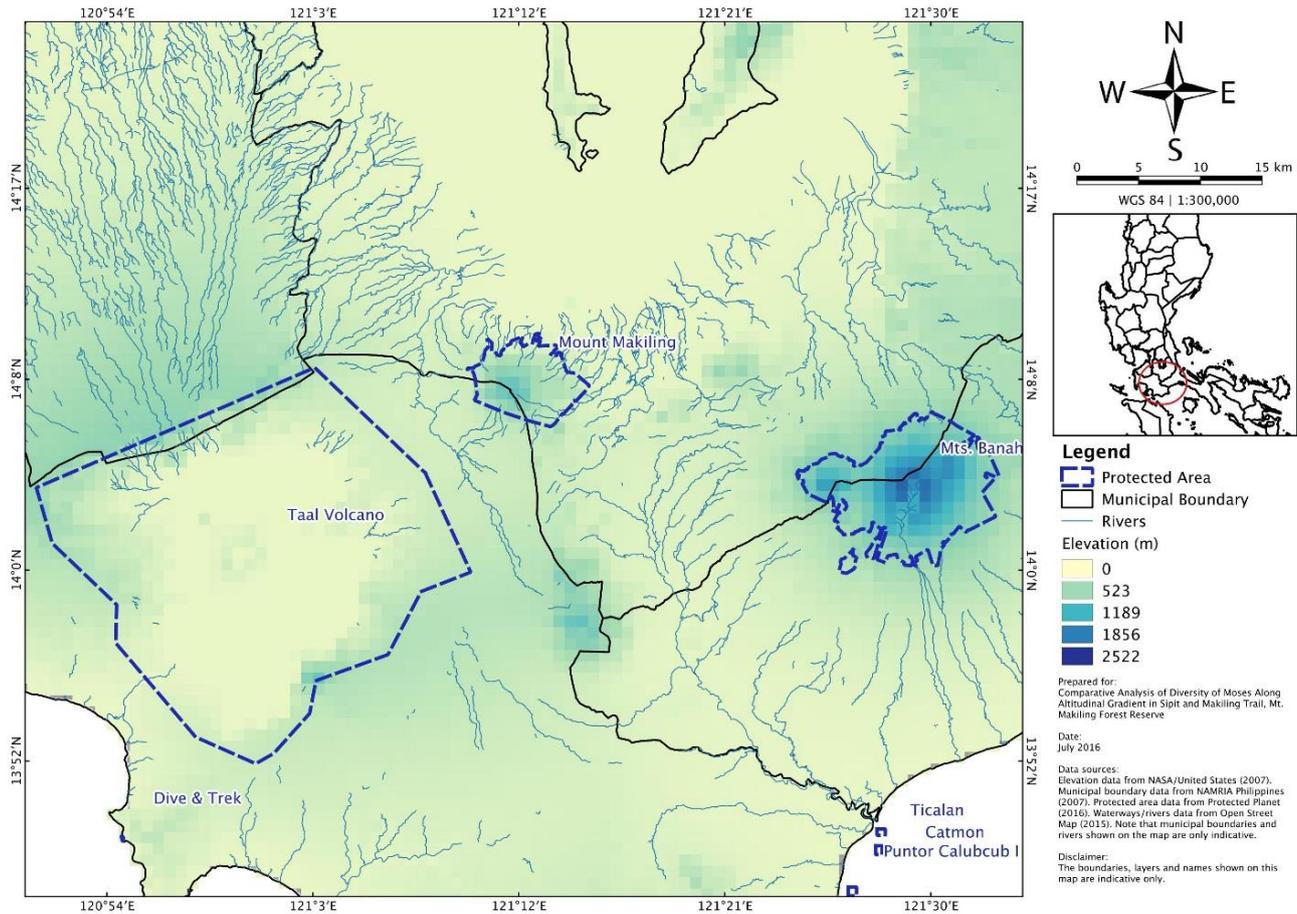


Figure 1. Location map of Mt. Makiling Forest Reserve, Philippines

Table 1. GPS reading of sampling plots in Makiling and Sipit trails Philippines

Plot no.	GPS reading			
	Makiling trail		Sipit trail	
	Northing	Easting	Northing	Easting
1 (300 m. asl)	14.141944	121.230306	14.11126	121.18680
2 (400 m. asl)	14.136056	121.229222	14.11744	121.18594
3 (500 m. asl)	14.129528	121.210944	14.12008	121.18507
4 (600 m. asl)	14.13375	121.208056	14.12076	121.18314
5 (700 m. asl)	14.138528	121.205250	14.12289	121.18434
6 (800 m. asl)	14.139222	121.199028	14.12485	121.18464
7 (900 m. asl)	14.137917	121.196806	14.13172	121.18451
8 (1000 m. asl)	14.136194	121.195722	14.13309	121.18458

Prior to the collection proper, a reconnaissance survey was conducted in the study area along an altitudinal gradient as a confirmatory step to verify the presence of mosses in the area. Using the Global Positioning System (GPS), the elevation and geographical location of the sampling plots were determined (Table 1).

Field methods

Modified belt transect method was used to survey the moss bryoflora in two (2) forest trails of Mt. Makiling. Altitudinal transect plots using modified belt transect

method were laid out in a left to right manner parallel to the existing trail (as transect line). Plots were laid out starting at 300 m. asl to 1,000 m. asl. From the trail, a two-meter length or distance was measured to the left and two meters to the right. Sixteen (16) sampling plots measuring 10m x 10m were established where moss samples were collected and studied (Figure 2).

Mosses found in different substrate (ground, rock or tree) were collected within sampling plots. Stand-up technique (after Shevock et al. 2014) was used in processing the voucher specimen.

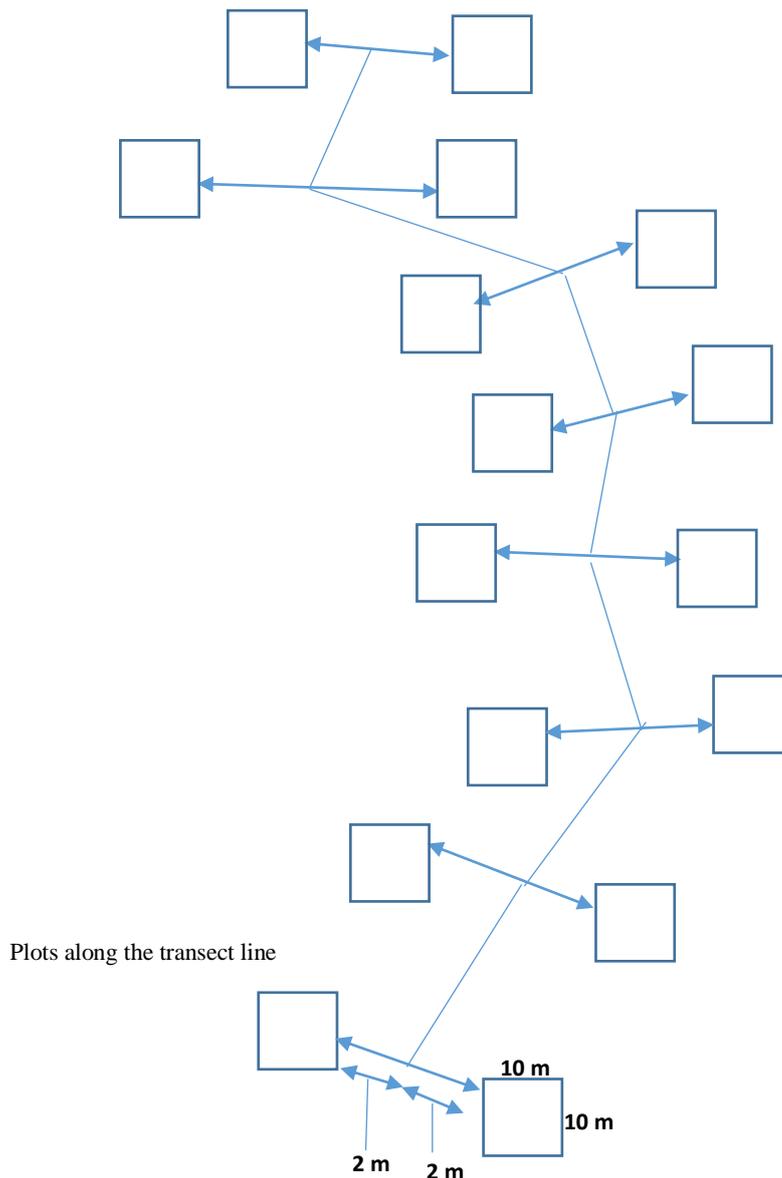


Figure 2. The modified belt transect method

Species identification

Moss specimens were photo-documented in situ. Specimens were re-examined under a dissecting microscope at the Forest Biological Sciences laboratory, College of Forestry and Natural Resources, University of the Philippines Los Baños (FBS, CFNR, UPLB). The samples were identified following Bartram (1939) and Tan and Iwatsuki (1991) using recent taxonomic treatment for mosses. Bartram's *Mosses of the Philippines* was used in identifying the specimens. The morphology and diagnostic characters such as characters of the stem, stem leaves, branch leaves, capsule, seta and the calyptra (if present) were used for classification.

Data analysis

Analysis of species richness and composition between the two trail communities were performed using R software v. 3.2.1. R (Tippmann 2015).

NMDS ordination technique was used to determine moss compositional pattern between the two trails. Map of plots was constructed in community composition space using a community dissimilarity matrix based from Euclidean distances.

The distribution of moss species along an altitudinal gradient was determined and plotted each species richness, species diversity H (Shannon diversity), and abundance against elevation. Species turnover analysis was presented to interpret moss flora composition along altitudinal gradient using the R package and calculates total turnover as well as the proportion of species that either appear or disappear between altitudinal sampling plots in each trail communities.

RESULTS AND DISCUSSION

A total of 77 moss species belonging to 17 families with 44 genera were identified in plots established in two altitudinal trail communities in MMFR. This accounts for 50% of the total moss species in Mt. Makiling and ~11% of the total moss species listed in the country (Tan and Iwatsuki 1991). Only 14 species (18%) belonging to 12 families were common to both trail communities. Hypnaceae is the most represented family with 14 species, followed by Calymperaceae (9 spp.), Sematophyllaceae (8 spp.), Fissidentaceae (7 spp.) and Neckeraceae and Leucobryaceae (6 spp.). The five most abundant species were *Leucoloma molle* (C. Mull.) Mitt. with 15 individuals, followed by *Taxithelium instratum* (Brid.) Broth (10), *Arthrocormus schimperi* (Dozy & Molk.) Dozy & Molk and *Lorentzia bifaria* (Bosch & Lac.) Buck & Crum (8) and *Calymperes subintegrum* Broth. (7).

Between the two trails, Sipit Trail has a higher species richness with 48 moss species compared to Makiling trail's 43 species. Seventy-one percent (71%) of moss families are common to both trails. These include family Brachytheciaceae, Calymperaceae, Dicranaceae, Fissidentaceae, Hypnaceae, Hypnodendraceae, Leucobryaceae, Meteoriaceae, Neckeraceae, Pterobryaceae, Sematophyllaceae and Thuidiaceae. The remaining 29% of moss families were characterized as unique to both Sipit and Makiling trails. These are species belonging to families Funariaceae, Hookeriaceae, Pottiaceae, Polytrichaceae and Stereophyllaceae. These show that the moss family composition in the two trails is almost the same.

Species richness comparison between trails

Makiling trail's moss flora belong to 14 families under 29 genera with Calymperaceae as the most represented family having 6 species (*Calymperes subintegrum* Broth.; *C. subserratum* M. Fleisch.; *C. tenerum* C. Mull.; *M. cf flavum*, *Syrrhopodon aristifolius* Mitt. and *S. loreus* (Lac.) Reese) followed by Fissidentaceae and Neckeraceae with 5 species each (*Fissidens crenulatus* var. *elmeri* (Broth.) Iwats. & Suzuki; *F. hollianus* Dozy & Molk.; *F. hyalinus* Hook. & Wils.; *F. laxus* Sull. & Lesq. and *F. zippelianus* var. *robinsonii* (Broth.) Iwats. & Suzuki; *Himantocladium plumula* (Nees) Fleisch.; *Homaliodendron exiguum* (Bosch & Lach) Fleisch.; *H. flabellatum* (Sm.) Fleisch.; *Pinnatella mariei* (Besch.) Broth. and *Neckeropsis lepineana* (Mont.) Fleisch).

The most dominant species found in Makiling trail are *Leucoloma molle* (C. Mull.) Mitt., *Arthrocormus schimperi* (Dozy & Molk) Dozy & Molk., *Calymperes subintegrum* Broth. and *Lorentzia bifaria* (Bosch & Lac.) Buck & Crum. These species belong to family Dicranaceae, Leucobryaceae, Calymperaceae, and Thuidiaceae, respectively. These were anchored to tree barks, trunks, branches, and dead/fallen logs. Majority of the species were thriving on trees (88.4%), followed by those on rock and soil substrate with 9.3% and 2.3%, respectively. This preference could be due to the availability of water and nutrient in tree trunks which is favorable for vigorous

growth of most bryophytes (Goffinet and Shaw 2009).

Leucoloma molle (C. Mull.) Mitt. can be found in higher elevations (1,000, 900, 800 and 700 m. asl) and *Arthrocormus schimperi* (Dozy & Molk.) Dozy & Molk. can be located in 1,000 and 900 m. asl. While *Calymperes subintegrum* Broth. can be found in 700 and 600 m. asl and *Lorentzia bifaria* (Bosch & Lac.) Buck & Crum can be found in lower elevations (600, 400 and 300 m. asl). Obviously, abundance of mosses was observed in higher elevations than in lower elevations. In this study, abundance increase with increasing altitudes. Relative moisture increases as altitude increases (Myers et al. 2000). Abundance is more likely because of their relative moisture conditions that are suitable habitat for bryophytes.

In Sipit trail, moss flora belongs to 16 families under 32 genera with Hypnaceae as the most represented family having 10 species (*Ectropotheciella distichophylla* (Hampe) Fleisch., *Ectropothecium falciforme* (Dozy & Molk.) Jaeg., *E. perminutum* Broth ex Bartr., *Glossadelphus zollingeri* (C. Mull.) Fleisch., *Isopterygium pendulum* Dix. ex Bartr., *Trachythecium micropyxis* (Broth.) Bartr., *Vesicularia dubyana* (C. Mull.) Broth., *V. montagnei* (Bel.) Broth., *V. reticulata* (Dozy & Molk.) Broth. and *Taxiphyllum taxirameum* (Mitt.) Fleisch.), followed by Calymperaceae with 6 species (*Calymperes erosum* C. Mull., *C. graeffeanum* C. Mull., *C. subintegrum* Broth., *C. tahitense* (Sull.) Mitt., *C. tenerum* C. Mull. and *Syrrhopodon aristifolius* Mitt.) and Leucobryaceae and Sematophyllaceae with 5 species each (*Arthrocormus schimperi* (Dozy & Molk.) Dozy & Molk., *Leucobryum scalare* C. Mull. ex Fleisch., *L. neilgherrense* Mull. Hal., *Leucophanes candidum* (Schwaegr.) Lindb., and *L. octoblepharioides* Brid.) and *Acanthorrhynchium papillatum* (Harv.) Fleisch., *Acroporium sigmatodontium* (C. Mull.) Fleisch., *Taxithelium gottscheanum* (Hampe ex C. Mull.), *Taxithelium instratum* (Brid.) Broth. and *Taxithelium nepalense* (Schwaegr.) Broth.

The most dominant species found in Sipit trail are *Taxithelium instratum* (Brid.) Broth., *Stereophyllum anceps* (Bosch & Lac.) Broth. and *Ectropotheciella distichophylla* (Hampe) Fleisch. These species belong to family Sematophyllaceae, Stereophyllaceae and Hypnaceae, respectively. These are mostly grown on trees (bark, branch, base, trunk), rock, and soil substrate. Sipit trail is a forested, slightly rolling, rocky and undisturbed area with favorable moisture condition or environment and good for the growth of mosses. Majority of the species were thriving on trees (58%), followed by those of rock and soil substrate with 33.3% and 8.3%, respectively. Similar with data on Makiling trail, the highest number of moss species were located on trees due to its moisture content, water and nutrients found on this substrate (Goffinet and Shaw 2009).

Family Hypnaceae can be found in both high and low elevations and this is same with family Calymperaceae, Leucobryaceae and Sematophyllaceae. These families are distributed in low and high elevations because of wind dispersal of spores. It might be blown by the wind from a higher to lower place. This was explained in the study of

Johansson et al. (2015), that higher proportion of the spores reached high altitudes through wind speed.

Seventy-one percent (71%) of family of moss are common to both Sipit and Makiling trails. These include family Brachytheciaceae, Calymperaceae, Dicranaceae, Fissidentaceae, Hypnaceae, Hypnodendraceae, Leucobryaceae, Meteoriaceae, Neckeraceae, Pterobryaceae, Sematophyllaceae and Thuidiaceae. The remaining 29% of family of moss were characterized as unique to both Sipit and Makiling trails. These are species belonging to families Funariaceae, Hookeriaceae, Pottiaceae, Polytrichaceae and Stereophyllaceae. Collectively, almost three-fourths (3/4) of the moss family are normally found in both trails while more than one-fourth (1/4) of the moss family are exclusively found in both trails. These data emphasized that the family composition in Sipit trail is almost the same as the families found in Makiling trail. It is proven that MMFR is an untouched area and rich moss flora diversity.

All elevations of Sipit and Makiling trail have unique species of mosses. Elevation 900 and 1000 m. asl have more unique species with 18 species each, followed by 17 species at 700 m. asl. The least unique species were found in 300 m. asl. This result may indicate that the elevation has significant factor for outcome of uniqueness of species of moss. This was positively the same with the results obtained by some authors regarding high elevation with more unique species compared to lower elevation (Geffert et al. 2013).

Moss species turn over along elevation

In Sipit trail, the highest species turnover was found in 1000 m. asl with 16 species and the lowest species turnover was found in 600 m. asl elevation (2 species). On the other hand, the highest species turnover in Makiling trail was observed in 900 m. asl with 11 species and lowest species turnover was found in 300 m. asl with only 3 species (Figure 3).

As noted, the species turnover showed variable fluctuations in the species composition in Makiling and Sipit trail. Species turnover gives the proportion of species that either appears or disappear between altitudinal points. In Sipit trail, plots at 500 and 600 m. asl have no species in common, while plots sampled at 300 and 400 m. asl have more species in common. Elevation of 1000 m. asl is the most undisturbed among elevations in Sipit trail. In Makiling trail, high species turnover was observed every altitudinal plot, with plot sampled at 900 to 1000 m. asl having the most species common.

Furthermore, plots located in high elevation showed higher moss abundance. These were also explained by the works of Gradstein and Pocs (1989) which explain this abundance as a result of more favorable moisture conditions due to clouds and fog and the prevailing lower temperatures. The same results were also found by Gonzales-Mancebo and Hernandez- Garcia (1996) in their research on the life strategies of mosses in the Canary Islands.

Generally, the lower diversity and abundance of mosses in lower elevation could be explained by the presence of anthropogenic and natural disturbances as well as the occurrence of open or unforested patches compared with the more conserved and forested areas at higher elevations.

Moss flora species richness and composition analysis

The result from non-metric multidimensional scale (NMDS) ordination plot showed little divergence between trail communities (Figure 4). In this figure, gray lines indicate paired-site altitudinal plots. Black text in each NMDS plots indicates plot names (GSS = Greater Sipit Subwatershed; MKL = Makiling). Black circles indicate groupings of high and low elevation plots. Communities that have very similar species composition appeared as points near each other whereas communities that have very different species compositions will further away from each other on the ordination plot.

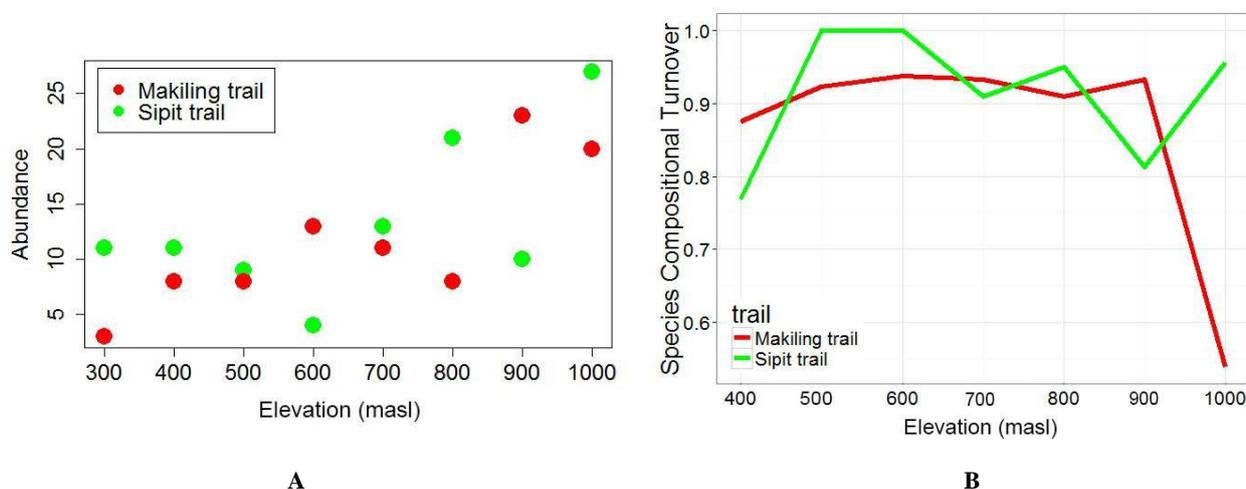


Figure 3. Altitudinal structure of moss species in MMFR using (A) species abundance and (B) composition

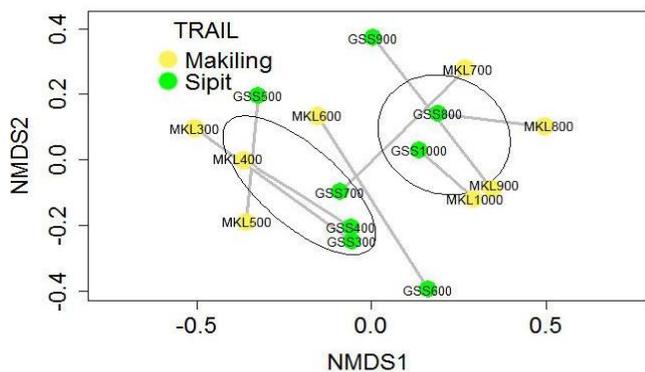


Figure 4. Non-metric multidimensional scale (NMDS) ordination of community composition relative to species abundance in Makiling trail (yellow plots) and Sipit trail (green plots).

Reading in NMDS plots is quite straightforward such that plots constructed in the ordination map that are closer to one another, are likely to be more similar than those further apart. In this result, altitudinal plots with relatively similar communities were plots at 1000 and 900 m. asl in Makiling trail, and plots 300 and 400 m. asl in Sipit trail. NMDS plots in the ordination map showed more affinity to altitudinal (elevation) position of the plots rather than trail community differences, as shown by plot groupings between higher and lower elevation plots, with exception to plot sampled at 700 m. asl in Sipit trail grouping along with lower elevation plots (Figure 4). Also, species composition at altitudinal paired plots is not similar given the long distance (gray line) between paired plots (Figure 4). The result indicates that compositional pattern in MMFR might be related to the present forest types along altitudinal gradient rather than aspect.

Recommendation

Data collection for moss species richness, diversity, and composition was conducted over a single season (dry season); therefore, it is recommended that a study covering an expanded sampling period (both wet and dry seasons) be conducted. Mosses are particularly sensitive to anthropogenic disturbance. Low moss diversity (richness, diversity H, and abundance) was observed in lower elevation plots which can be related to proximity to human activities. Therefore, forest along low elevation should be addressed for protection and conservation in MMFR, since moss has a significant role in the ecosystem. Furthermore, it is recommended that the moss diversity and composition of the Northeast and Southeast portions of MMFR be compared to this study. Moreover, these could be compared to other similar forest reserves in the Philippines having the same altitudinal gradients.

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