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Distribution and Diversity of Myxomycetes Along the Elevational Belt of Mt. Calavite Wildlife Sanctuary (MCWS), Occidental Mindoro, Philippines

Christon Jairus M. Racoma [1,2], John Carlo Redeña-Santos [2,3] and Nikki Heherson A. Dagamac [1,2,3,4,*]

[1] The Graduate School, University of Santo Tomas, Espana Blvd., Manila 1008, Philippines; jairusracoma@gmail.com
[2] Initiatives for Conservation, Landscape Ecology, Bioprospecting, and Biomodelling (ICOLABB), Research Center for the Natural and Applied Sciences, University of Santo Tomas, Espana Blvd. 1015, Manila 1008, Philippines; santosjcarlo@gmail.com
[3] D'ABOVILLE Foundation and Demo Farm Inc., Makati 1200, Philippines
[4] Department of Biological Sciences, College of Science, University of Santo Tomas, España Blvd. 1015, Manila 1008, Philippines
* Correspondence: nhadagamac@gmail.com

Abstract: Myxomycetes are protists that predate microbial communities in soil and are heavily affected by changing climate conditions. As seen in a more distinct guild of myxomycete, their fructification diversity depends not only on the heterogeneity of vegetation but also on temperature and precipitation. To determine the reverse pattern of microbial diversity established in temperate ecozones, foliar and lignicolous litters were collected along a tropical montane site in the Philippines. Fifty-seven (57) morphospecies of myxomycetes from 15 genera were determined. Alpha-diversity analysis revealed a significant decline in species richness and diversity with increasing elevation. Beta-diversity analysis, integrating non-metric multidimensional scaling (NMDS), PERMANOVA, and hierarchical clustering, revealed the complex relationships between species turnover and community composition across elevational gradients. These results conform to the hypothesis that species richness decreases as elevation increases, supporting that tropical ecozones follow the general trend of myxomycete diversity that was first observed in the temperate ecozones. The strong role of elevation in shaping myxomycete community structure is further emphasized. This indicates that conservation management efforts should become more stringent in the areas found at the lower elevation of a tropical montane forest, which are more ecologically sensitive to human-induced stressors and climate-related pressures.

Keywords: biodiversity pattern; elevational diversity gradient hypothesis; eumycetozoan; microbial ecology; Paleotropic; protists; slime molds; tropical diversity

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1. Introduction

The driver in diversification patterns on environmental gradients comes from the influence of altitude and latitude that revolves around biogeographical and ecological studies based on occurrences and patterns recognized along elevational biodiversity [1,2]. Protists from eukaryotic taxa, such as fungi, plants, and animals, can be found in soil systems, exhibiting a broad range of diversity [3]. A deep branch of the eukaryotic tree, the supergroup Amoebozoa, includes all lobose amoebae—naked and testate—mycetozoans, anaerobic archamoebians, and organisms that possess flattened, branching reticulate, or flagellated structures, which were subdivided into a current primary subclade: Tubulinea,

Evosea (which encompasses Eumycetozoa, Variosea, Archamoebae, and Cutosea) and Discosea [4,5]. Eumycetozoans, or slime molds, are the most diverse group of Amoebozoa, with myxomycetes being the most well-known species that produce spores in their fruiting bodies and can be found in all terrestrial ecosystems [6,7]. Myxomycetes have distinct body structures and life cycles, which begin with the germination of myxamoeba/amoeboflagellate cells, which subsequently form plasmodia [8]. Myxomycetes fruiting body development arises from plasmodia and culminates through spore dispersal that can reach long distances of more than a kilometer, enabling successful propagation; spores are then used to characterize for species identification [9–11]. Myxomycetes are ecologically important detritivores for maintaining ecosystem balance through decay facilitation, playing a role in nutrient recycling and potentially contributing to bioremediation [12,13], at which they can be most efficient in tropical regions due to complex structural-forming microhabitats [14]. The distribution, ecology, and biology of myxomycetes have expanded significantly, while their taxonomy has remained relatively stable over time amongst other groups [15,16]; however, their intraspecific taxonomy has been under debate, with molecular data challenging their traditional classification yet still insufficient to assign species-level relationships [17].

In recent years, research on myxomycetes in the Philippines has progressed from simply anecdotal records [18,19] and their occurrences [20,21] to conducting diversity studies [22–24] and has even delved into areas such as predictive modeling [25] and exploration for biotechnological possibilities [26]. Most diversity studies conducted in the Philippines have solely focused on comparing species assemblages from various litter types and different geographic or neighboring locations [27]. However, investigations on the elevational distribution and diversity remain challenging, as the only prior study examining the correlation between elevation and microclimatic conditions was carried out by [28]. However, this investigation resulted in the contradiction of previous findings on the impact of elevation on myxomycetes diversity—species diversity decreased with increasing elevations [29,30]. Although these findings were from the Neotropics regions, a recent study by [12] from Southern Vietnam, a neighboring country of the Philippines, found that the same trend holds true in the Asian Paleotropics, further suggesting that an increase in moisture correlates to lower species richness and abundance.

The distribution and diversity of myxomycetes along elevational gradients are still not well understood in tropical montane regions such as the Philippines, despite the significant roles they play in ecology. Although earlier studies attempted to generally investigate diversity patterns and species assemblages in various habitats, they have often failed to consider the natural setbacks in conducting such studies in the tropics—(i) challenging terrains, (ii) unpredictable seasonality, (iii) bureaucracy in permit acquisition, and (iv) heterogeneity of plant communities that could heavily affect the fieldwork activity. Nevertheless, the spatial aspects that could directly influence myxomycetes, including elevation and microclimatic conditions, remain a feasible ecological question in the Philippines, whose habitat conservation selection on protected sites is considered patchy and unreliable.

Mount Calavite Wildlife Sanctuary (MCWS) used to be covered in forests until the 1990s, when the low-lying surrounding plain areas were cleared for agriculture, resulting in the creation of extensive cogonal regions; however, it is now a protected area under the wildlife sanctuary classification according to the National Integrated Protected Areas Systems Act [31]. A protected area is ideal for research exploration mainly due to its rich biodiversity, minimal human disturbance, and the potential for contributing valuable data that can inform conservation approaches. There were no previous studies conducted in MCWS; hence, this synecological research explored protected natural forests in an isolated island of the archipelago in terms of traditional myxomycete fructification to (i) compare the distri-

bution patterns of myxomycetes species in the ASEAN region, as driven by environmental factors—seasonal variability and substrate type, (ii) provide comprehensive and corroborative distribution and diversity of myxomycetes morphospecies on elevational gradient, and (iii) report the first list of myxomycete assemblages in MCWS, Occidental Mindoro.

2. Materials and Methods

2.1. General Study Area

The Mount Calavite Wildlife Sanctuary (13°27′55.1″ N, 120°23′46″ E) is a steep mountain located in the Paluan municipality of Occidental Mindoro (Figure 1). The municipality was classified as Type I climate [32]. It comprises two distinct types of forests—tropical moist deciduous forest (TMDF) on lower elevations and tropical lower montane rainforest (TLMR) at higher elevations reaching up to 1521 m above sea level.

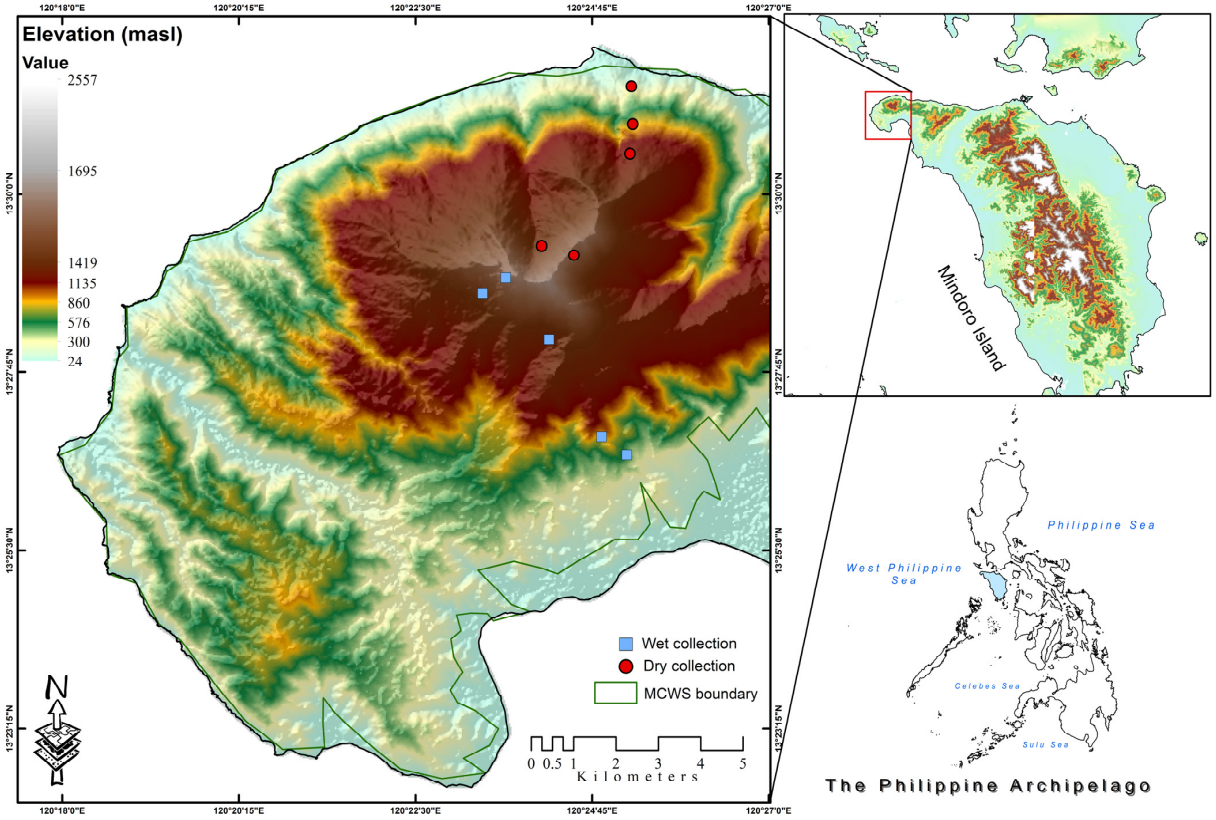

Figure 1. Study area map of Mount Calavite Wildlife Sanctuary, Occidental Mindoro, showing the elevational gradient and the sampling points collected during the wet season in the months of August to October and the dry season in the months of March to May.

2.2. Sample Collection, Processing, and Characterization of Myxomycetes

The protected area of MCWS was granted a gratuitous permit for the collection and duration of this study under the jurisprudence of the Department of Natural Resources and Environment—Mindoro, Marinduque, Romblon, and Palawan (DENR-MIMAROPA). After permit acquisition, this study determined five sampling sites, each spaced at intervals of 300 m until reaching the peak at an elevation of 1500 m above sea level (masl). The sampling sites represented different vegetation types and disturbance levels to some degree. The first sampling area was designated at the ranges of 0–300 masl, which was fairly disturbed due to the ease of accessibility for both local and indigenous people. At 301–600 masl is designated as the second sampling area and follows 601–900 masl, 901–1200 masl, and 1201–1500 masl at the peak. The sampling site per elevational gradient was an efficient

representation of each zone, capturing key ecological characteristics without redundancy while minimizing sampling effort, as field explorations tend to become more difficult as samples increase, which requires more time, effort, and resources. The sampling collection strategy employed composite-random sampling along the established and made trails that were considered safe, with the assistance of a local guide. At each site, three types of substrates were collected: ground litter (GL) found on the forest floor, aerial litter (AL) above the canopy cover, and wood (WD) consisting of decaying twigs and bark from vegetation. A total of 30 samples were collected, comprising 10 samples collected for each substrate at each sampling site. The sampling collection was done at a minimal time variation during different seasons, particularly the wet period, which spans from August to October, and the dry period, which includes the months of March to May.

The collected litter samples were dried in the open air to inhibit the growth of filamentous fungi and prevent the sample from further decomposing. This study utilized the Moist Chamber (MC) culture technique [33]. The protocol of this method involves placing small fragments of the substrate, such as leaves, twigs, barks, and other plant debris, in a Petri dish with anything that absorbs moisture, such as tissue or paper towel. A substantial quantity of water is introduced to establish a moist environment; any surplus water is drained. The dish is left undisturbed until the plasmodia and fruiting bodies become easily observable. Each sample of different substrates was placed in its own MC. Occasionally, the MCs were sprayed with distilled water to ensure their moisture was maintained. The MCs were situated in a laboratory at room temperature in an ambient environment.

The MCs were observed under a dissecting microscope (Olympus CX23, Olympus, Tokyo, Japan) in a span of 12 weeks, with weekly assessments to detect the presence of fruiting bodies. During the observation period, plasmodia or fruiting bodies were considered positive indicators of an MC, whereas their absence was considered negative [34]. The identification of myxomycetes species was determined by its fruiting body formation and spores. The morphological characteristics were compared to previously published literature in order to confirm the identification, such as published books [35], journals [36], and web-based taxonomic keys (https://www.uark.edu/search/index.php?searchStudioQuery=slimemold; http://www.discoverlife.org/; accessed on 8 June 2024). For the validation of the current and accepted taxonomic names, an online nomenclature database (http://nomen.eumycetozoa.com; accessed on 21 September 2024) was cross-referenced, which comprises all the groups of eumycetozoans [37]. The fruiting bodies of myxomycetes from MCs were delicately removed from their attached substrates for preservation as voucher specimens. Subsequently, they were placed in a pasteboard tray that had been precisely cut out to be enclosed in a small herbarium box that resembles a matchbox.

2.3. Data Evaluation and Analyses

Initial data were computed for the percent yield production of myxomycetes on MCs for each collection at different seasons, substrate types, and elevational ranges [38]. The observation period of the MC determines the growth of plasmodia or fruiting bodies, with negative chambers exhibiting no growth and positive chambers exhibiting growth [34]. The Abundance Indices (AIs) were assigned to all species in collections according to their relative abundance (RA), calculated as the proportion of the occurrence of a species to the total number of collections; such a threshold of 'breaking point" was determined based on these percentage values [39]. These were classified in the ACOR scale as follows: A-abundant (>3%), C-common (>1.5% but <3%), O-occasional (>0.5% but < 1.5%), and R-rare (<0.5%).

Data analyses were consistently performed in R language (R version 4.3.3) [40]. In estimating the extent of the sampling collection for its exhaustiveness, a species accumulation

curve (SAC) for identified species of myxomycetes was constructed following the 'iNEXT' (iNterpolation/EXTrapolation) package in accordance with the basic functions for calculating and graphing R/E sampling curves based on sample size and coverage, as well as confidence bands [41]. The species composition was used to determine the alpha diversity by recording the presence or absence of fruiting bodies on each seasonal collection across different elevational ranges from different substrate types. An MC containing a species of fruiting body myxomycetes was classified as a single positive collection (a taxonomic unit proxy). Therefore, its repeated presence from another chamber was recorded as an occurrence [38]. Analyses on alpha- and beta-diversity utilized the 'vegan' package [42]. The alpha-diversity of the myxomycetes species is determined using the following different indices: Simpson's (D_s) index, Shannon's (H') index, and their derivatives: Shannon Exponential and Inverse Simpson [43–45]. It was visualized using the 'ggstatsplot' package [46]. From this, non-parametric tests were applied to evaluate the differences among the diversity indices. The effect sizes among the differences were also computed with confidence intervals (95% CI) provided for each index. Conversely, post hoc pairwise comparisons (Dunn's test) were performed to identify the differences among the diversity indices from one another, applying the default method (Holm's method) to adjust *p*-values for multiple comparisons. Significant pairwise differences were highlighted and displayed graphically using lines. The most probable abundance distribution model for assessing the species of myxomycetes across different elevational ranges, substrate types, and seasonal collections utilized the rank abundance curves, where species are arranged in a sequential order based on their abundance [47]. We tested the following five models [48]: Null (fits the broken stick model), Preemption (fits the geometric series or Moto-mura model), log-Normal, Zipf, and Mandelbrot to assess the degree of dominance and evenness [49]. The species composition of the myxomycetes among elevational ranges, substrate types, and seasonal collections was determined using non-metric multidimensional scaling (NMDS), employing the Euclidean measure for dissimilarity (k = 2; maximum iterations = 999); PERMANOVA analysis; and clustering analysis through neighbor-joining clustering tree utilizing Bray–Curtis dissimilarity and Jaccard similarity indices [49,50]. Two hypotheses—species decreases as elevation increases and the mid-domain hypothesis—were visualized through simulation using the Monte Carlo model (k = 1000) to calculate species richness along an elevational gradient in comparison with the observed species richness data.

3. Results

3.1. Percent Yield

A total of 300 MCs were prepared from different collected substrates from the two-collection season at different slopes of MCWS. In total, there are 294 fruiting bodies of myxomycetes that were recorded; hence, the total positive productivity led to 199 MCs (66%), from which 45 (22.61%) yielded non-fruiting bodies (sclerotia or plasmodia only). The highest percentage yield for positive productivity was observed for 0–300 masl (78.33%), followed by 301–600 masl (75%), 601–900 masl (68.33%), and 901–1200 masl (61.67%). Whereas at the highest elevation, five (1201–1500 masl) had a relatively low yield of 46.67%. The MC cultures where non-fruiting bodies were present (plasmodia and/or sclerotia) were found to have the greatest percent yield from the higher elevations: 1201–1500 masl (53.33%), 901–1200 masl (31.67%), and 601–900 masl (38.33%). On comparing the seasons, the wet season yielded 68.67% productivity, while it was 63.33% for the dry season. Among the substrates collected, ground litter exhibited the highest positive productivity, with the relative percent from aerial litter being 72% and 67%, respectively; the least was from wood (59%).

3.2. Species Occurrences, Diversity and Distribution

A total of 57 species of myxomycetes belonging to 15 genera were observed and identified (Table 1) across different collected substrates from the two-collection season at different slopes of MCWS. These species belong to the families *Arcyriaceae*, *Stemonitidaceae*, *Cribrariaceae*, *Didymiaceae*, *Physaraceae*, and *Trichiaceae*. The distribution pattern of species greatly varies with relative abundances. From the computed relative abundances, *A. cinerea* was the only one categorized as abundant and collected during the wet season. Didymium squamulosum was observed as common, whereas *Diderma hemisphaericum* and *Perichaena depressa* were noted as occasionally occurring, making up ≥5% to <10% of the entire collection. The rest of the myxomycete species in this study were observed and recorded as rare across different elevational ranges.

Table 1. Abundance indices of recorded fruiting body species of myxomycetes collected at different seasons on five elevation sites from various substrate types in Mount Calavite Wildlife Sanctuary, Occidental Mindoro, Philippines (*n* = 296).

	Seasons		**Elevation Sites**					**Substrates**		
Taxon	Wet	Dry	1	2	3	4	5	GL	AL	WD
Arcyria affinis Rostaf		R		R				R	R	C
Arcyria cinerea (Bull.) Pers.	A	C	O	O	C	R	R	C	O	C
Arcyria globosa Schwein.	R	R	R	R		R		R		R
Arcyria incarnata (Pers. ex J.F. Gmel.) Pers.	R	R	R	R					R	
Arcyria obvelata (Oeder) Onsberg	R	R	R	R	R		R	R	R	R
Collaria cf. *arcyrionema* (Rostaf.) Nann-Bremek. ex-Lado	R			R	R			R		R
Comatricha cf. *ellae Härk*	R			R				R		
Comatricha fragilis Meyl.	R			R					R	
Comatricha nigra (Pers. ex J.F. Gmel.) J. Schröt.	R	R	R			R				R
Comatricha pulchella (C. Bab.) Rostaf.	R			R					R	
Comatricha cf. *suksdorfii Ellis* & Everh	R			R						R
Comatricha tenerrima (M.A. Curtis) G. Lister	R			R	R					R
Cribraria macrocarpa Schrad.		R			R					R
Cribraria piriformis Schrad.	R					R			R	
Cribraria cf. *tenella* Schrad	R		R			R		R	R	
Cribraria violacea Rex	R	R	R	R				R	R	R
Cribraria cf. *languescens* Rex	R				R					R
Cribraria cf. *tecta* Hooff	R			R						R
Diachea bulbillosa (Berk. & Broome) Lister		R	R						R	
Diderma effusum (Schwein.) Morgan	R	R	R		R			R	R	
Diderma hemisphaericum (Bull.) Hornem.	O	O	O	R	R	R		O	O	R
Diderma cf. *montanum* (Meyl.) Meyl.	R			R					R	
Diderma testaceum (Schrad.) Pers.	R					R		R		
Didymium columella-cavum Hochg, Gottsb et Nann -Bremek	R			R	R			R		
Didymium difforme (Pers.) Gray	R		R	R	R			R	R	
Didymium nigripes (Link) Fr.	R	R	R			R	R	R	R	R
Didymium serpula Fr.	R			R					R	
Didymium squamulosum (Alb. & Schwein.) Fr. & Palmquist	C	R	O	R	R	R	R	O	O	R
Didymium verrucosporum A.L. Welden	R	R	R	R				R	R	
Hemitrichia calyculata (Speg.) M.L.Farr	R			R	R			R	R	
Hemitrichia cf. *minor* G. Lister	R					R				R
Hemitrichia serpula (Scop.) Rostaf. ex-Lister	R	R	R	R	R				R	R
Hemitrichia pardina (Minakata) Ing	R		R		R				R	R
Lamproderma scintillans (Berk. & Broome) Morgan	R		R							R
Lepidoderma tigrinum (Schrad.) Rostaf.	R			R					R	
Oligonema sp.	R		R							R
Ophiotheca chrysosperma (Curr.) Lister	R	R	R	R	R				R	O
Perichaena depressa Lib.	O	O	R	R	R	R	R	R	O	R
Perichaena dictyonema Rammeloo	R		R	R				R		R
Perichaena pedata (Lister & G. Lister) Lister ex E. Jahn	R		R					R		
Perichaena cf. *vermicularis* (Schwein.) Rostaf.	R		R							R
Physarum bitectum G.Lister		R			R				R	
Physarum bivalve Pers.	R				R	R		R	R	
Physarum cinereum (Batsch) Pers.	R	R	R			R		R	R	
Physarum compressum Alb. & Schwein.	R	R	R	R	R	R		R	R	
Physarum decipiens M.A. Curtis	R	R	R	R	R	R		R		R

Table 1. *Cont.*

	Seasons		Elevation Sites					Substrates		
Physarum diderma Rostaf.	R	R	R	R	R			R	R	
Physarum echinosporum Lister	R	R		R		R		R	R	R
Physarum gyrosum Rostaf.	R		R		R			R		
Physarum leucophaeum Fr. & Palmquist		R	R						R	
Physarum notabile T. Macbr.	R		R					R		
Physarum pusillum (Berk. & M.A. Curtis) G. Lister		R			R				R	
Physarum viride (Bull.) Pers.	R		R						R	
Stemonitis fusca Roth	R	R	R	R		R	R	R	R	R
Stemonitis pallida Wingate	R				R		R			R
Trichia cf. *persimilis* P. Karst.	R			R						R
Trichia cf. *scabra* Rostaf.	R		R							R
Species Richness (S)	51	26	33	32	24	17	7	28	33	30

A = abundant → ≥10% of the total collections; C = common → 5% < but <10% of the total collections; O = occasional → 3% < but <5% of the total collections; R = rare → ≤3% of the total collections.

The SACs (Figure 2) exhibited differences in varying species diversity for different substrate types, seasonal collections, and elevation ranges. In seasonal collection, the wet season had relatively more species recovered and projected (S = 51; estimated = 93.02) than in the dry season (S = 26; estimated = 40.99). Among the substrates collected, the aerial litter (S = 33) relatively harbored more species of myxomycetes and had the highest richness estimated (estimated = 86.47) among the three types collected. In addition, a slightly higher species diversity was recovered at elevation one (0–300 masl; S = 33; estimated = 142.14) but is more likely to be observed as high in comparison with elevation two (301–600 masl; S = 32; estimated = 81.28). It was followed by elevation three (601–900 masl; S = 24; estimated = 33.87), with a higher species observed and projected than elevation four (901–1201 masl; S = 17; estimated = 23.23), and the least significant was from elevation five (1201–1500 masl; S = 7; estimated = 7.36).

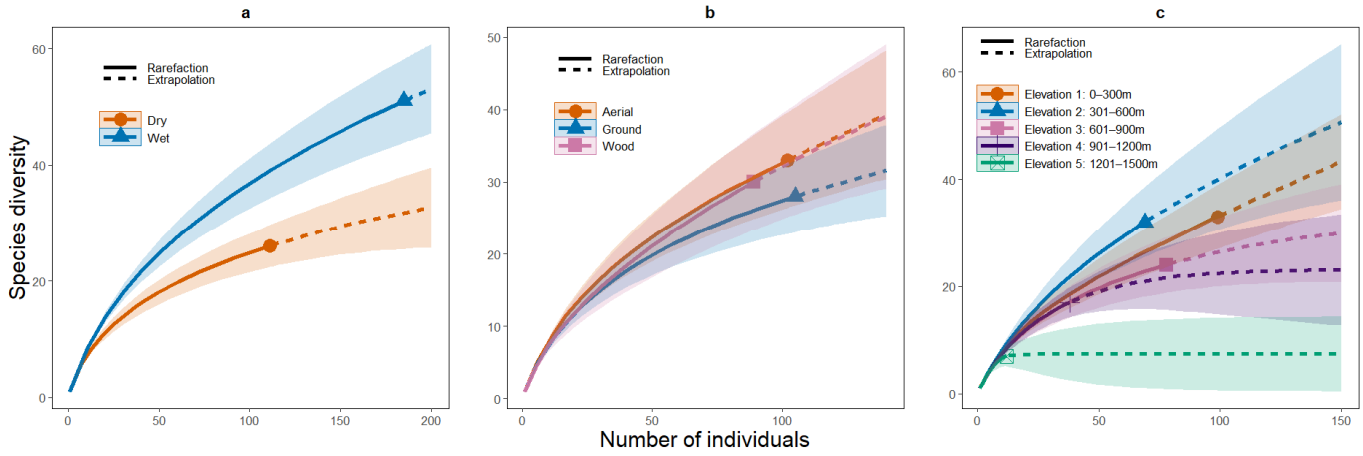

Figure 2. Species accumulation curves (SACs) of myxomycetes composition on MWCS across different (**a**) seasonal collections, (**b**) substrate types, and (**c**) elevational gradients. Shaded areas indicate confidence intervals (conf = 0.95) for the estimates. Sampling completeness—seasonal collection: dry (63.43%) and wet (54.83%); substrate types: aerial (38.16%), ground (61.10%), and wood (42.83%); elevational gradient: elevation 1 (23.22%), elevation 2 (39.37%), elevation 3 (70.86%), elevation 4 (73.18%), and elevation five (95.02%).

The rank abundance curves (Figure 3) tested for five different abundance distribution models showed comparable results, providing distribution patterns across ecological parameters—seasonal collection, elevation, and substrate type. For species abundance observed from different seasonal collections at wet seasonal collections, although the Zipf model exhibited parsimonious in terms of simplicity with a lower Bayesian Information

Criterion (BIC = 151.15), the Mandelbrot model was the best-fitting curve with a lower Akaike Information Criterion (AIC = 147.02). The slight increase in complexity using the Mandelbrot model is justified by the improved fit and the ability to better explain the species composition patterns observed, as supported by a lower deviance (4.66). This holds the same during the dry season, as the Mandelbrot model clearly displayed a well-fit curve with the lowest AIC (82.27) and BIC (86.05) that corresponds well with the observed data (deviance = 2.81). The species abundance distributions showed similar trends in both seasons, with the Mandelbrot model consistently describing the observed patterns. In both the dry and wet seasons, a small number of dominant species accounted for the majority of abundance, specifically *A. cinerea*, *D. hemisphaericum*, *D. squamulosum*, and *P. depressa*, while the remaining species were represented by low abundances.

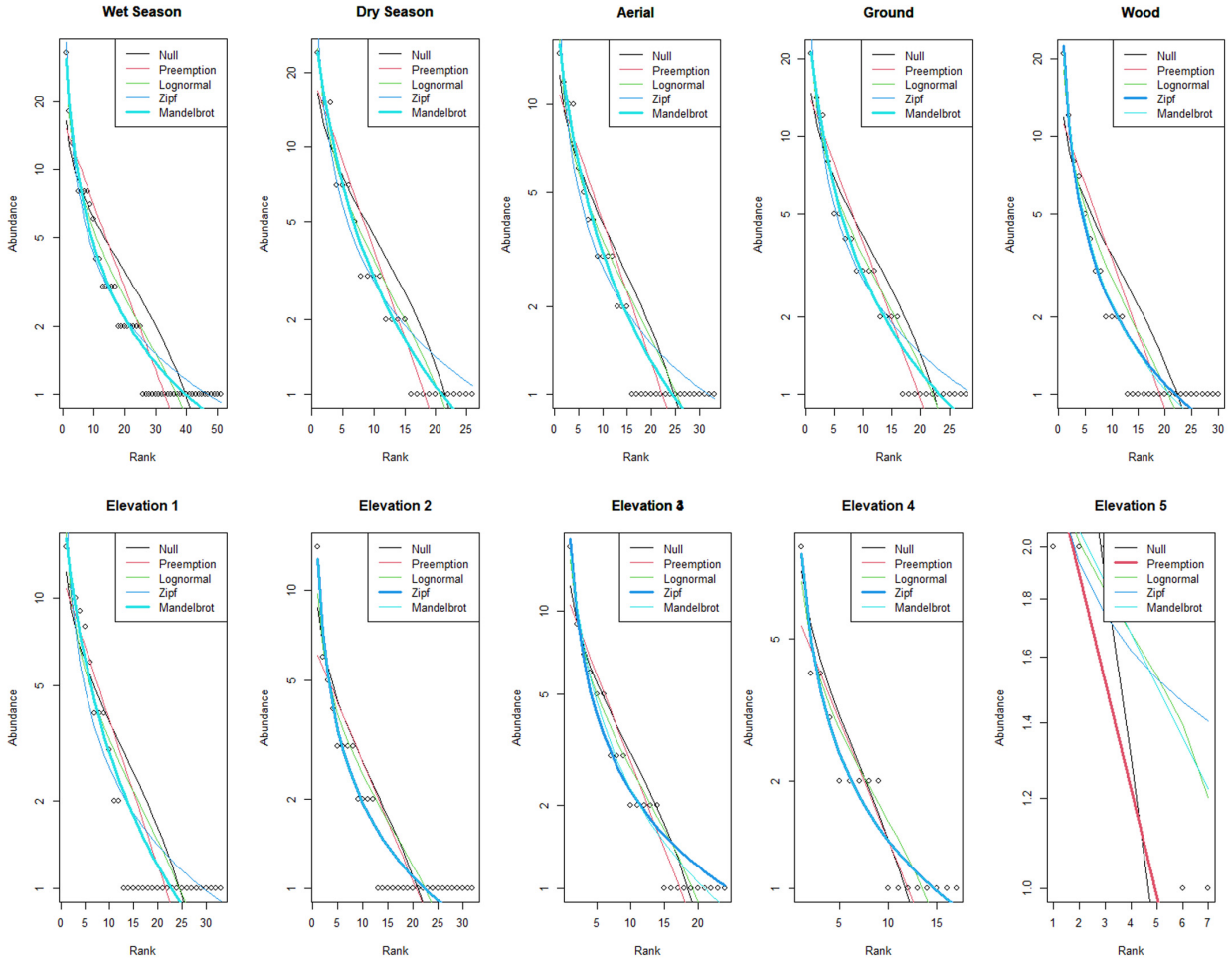

Figure 3. Rank abundance curve plots based on the abundance of species for different substrate types (aerial, ground, and wood), seasons (wet and dry), and elevational ranges (elevations 1, 2, 3, 4, and 5) testing five distribution models; thickened line represents best-fitting curve—Zipf model: shows how few species dominate in abundance, while many are rare; Mandelbrot model: shows where dominant species flatten in abundance and rare species decline sharply [51]; Preemption model: competitive species dominate initially due to abiotic factors, while subsequent species' abundances are influenced by competition [52,53].

Across the elevational gradient, the species abundance in elevation one (0–300 masl) was best represented by the Mandelbrot model, supported by a low AIC (95.68) balancing a strong fit with an acceptable level of model complexity based on this criterion, as compounded by a low BIC (100.17) and deviance (5.05). It was characterized by a strong dominance of a few species—*A. cinerea*, *D. hemisphaericum*, and *D. squamulosum*—accounting

for the majority of total abundance, while the majority of species were observed at lower abundances, which indicates that species abundance at this elevation follows a predictable dominance–diversity pattern. However, at elevation two (301–600 masl), the Zipf model best represented the species abundance with the lowest AIC (83.095) and BIC (86.026) values and deviance (1.78). Similarly, at elevation three (601–900 masl), the Zipf model was the preferred model as illustrated by a lower AIC (71.10) and BIC (73.46) as compared to the Mandelbrot model with a lower deviance (1.29). The same model applies at elevation four (901–1200 masl), which exhibited the lowest AIC (47.460) and BIC (49.126). The aforementioned model steadily emerged as the best-fit curve across the three elevations, as established by both low AIC and BIC values, which suggests a gradual decline in relative abundance across ranks, with fewer dominant species—such as *A. cinerea*—and a more even distribution among less abundant or rare species observed, or it may indicate reduced competitive exclusion, which allows more species to coexist compared to the Mandelbrot pattern observed at elevation one (0–300 masl). In contrast, at the highest elevation—elevation five (1201–1500 masl)—the Preemption model was best suited for explaining the species abundance with few species (n = 7) observed an abundance of 12, consistent with low AIC (20.72), BIC (20.66), and deviance (1.65) values. As demonstrated in a steep decline in relative abundance from the dominant species, it assumes few dominant species are present, with the remaining species occupying significantly smaller proportions of the community. This may be attributed to harsher environmental conditions or limited resources at the highest elevation, which could intensify competition and favor resource monopolization. The varying model observed across the elevational gradient implies a shift in species abundance patterns, potentially driven by fluctuating ecological changes such as competition dynamics, availability of resources, and environmental filtering.

While these transitions in elevational gradients infer broad-scale patterns of species distribution and community dynamics, the role of substrate type as a microhabitat factor warrants closer examination in understanding its influence on species composition and abundance. Consequently, for substrate types, the community in aerial litter was best represented by the Mandelbrot model, based on low AIC (95.53) and BIC (100.02) with a low deviance of 2.84. While the Zipf model offers a parsimonious explanation in terms of species abundance patterns, as indicated by a lower BIC (88.04), the Mandelbrot model presented the best fit to the community in ground litter with a lower AIC (85.19) and deviance (1.62). For the community in wood, although the Mandelbrot model provided the optimal fit to the observed species abundance distribution (deviance = 1.87), the Zipf model was more in balance between model fit and simplicity, as indicated by low AIC (82.26) and BIC (85.07) values. The species distribution on wood substrate suggests a resource-sharing environment, where species coexist more evenly and have relatively equal access to resources, leading to more balanced abundances. Meanwhile, the species distribution on aerial and ground substrates reflects resource exploitation, where a few dominant species preempt the most available resources, which leaves the rarer species for reduced opportunities, causing increased competition and driving the species into more specialized ecological niches.

The taxonomic diversity in terms of alpha measure for several estimators is displayed on violin plots (Figure 4). In seasonal collections, the wet season ($\hat{\mu} = 1.85$) had a higher species diversity than the dry season ($\hat{\mu} = 1.56$); the Mann–Whitney test showed a significant difference ($p < 0.05$) between the two seasons with a strong negative effect size ($\hat{r}_{\text{biserial}} = -0.48$) and confidence interval ($\text{CI}_{95\%}[-0.74, -0.10]$) that implies the directionality of the increase of species diversity when conditions shift from the dry to wet season. The Shannon Exponential index (Hill N1) had a similar finding of significance in difference ($p < 0.05$). The Simpson's index, on the other hand, showed no significant difference

($p > 0.05$) observed between the dry ($\hat{\mu} = 0.89$) and wet ($\hat{\mu} = 0.93$) seasons, with similar species evenness across the two seasons, although when the season shifts, a slight decrease in species evenness could be observed but with small-to-moderate practical significance as evidenced by effect size ($\hat{r}_{\text{biserial}} = -0.27$) and confidence interval ($\text{CI}_{95\%}[-0.60, -0.15]$). However, Inverse Simpson (Hill N2) revealed a significant difference ($p \leq 0.05$) between the dry ($\hat{\mu} = 4.34$) and wet ($\hat{\mu} = 5.76$) seasons, supporting higher species evenness and richness in the wet season.

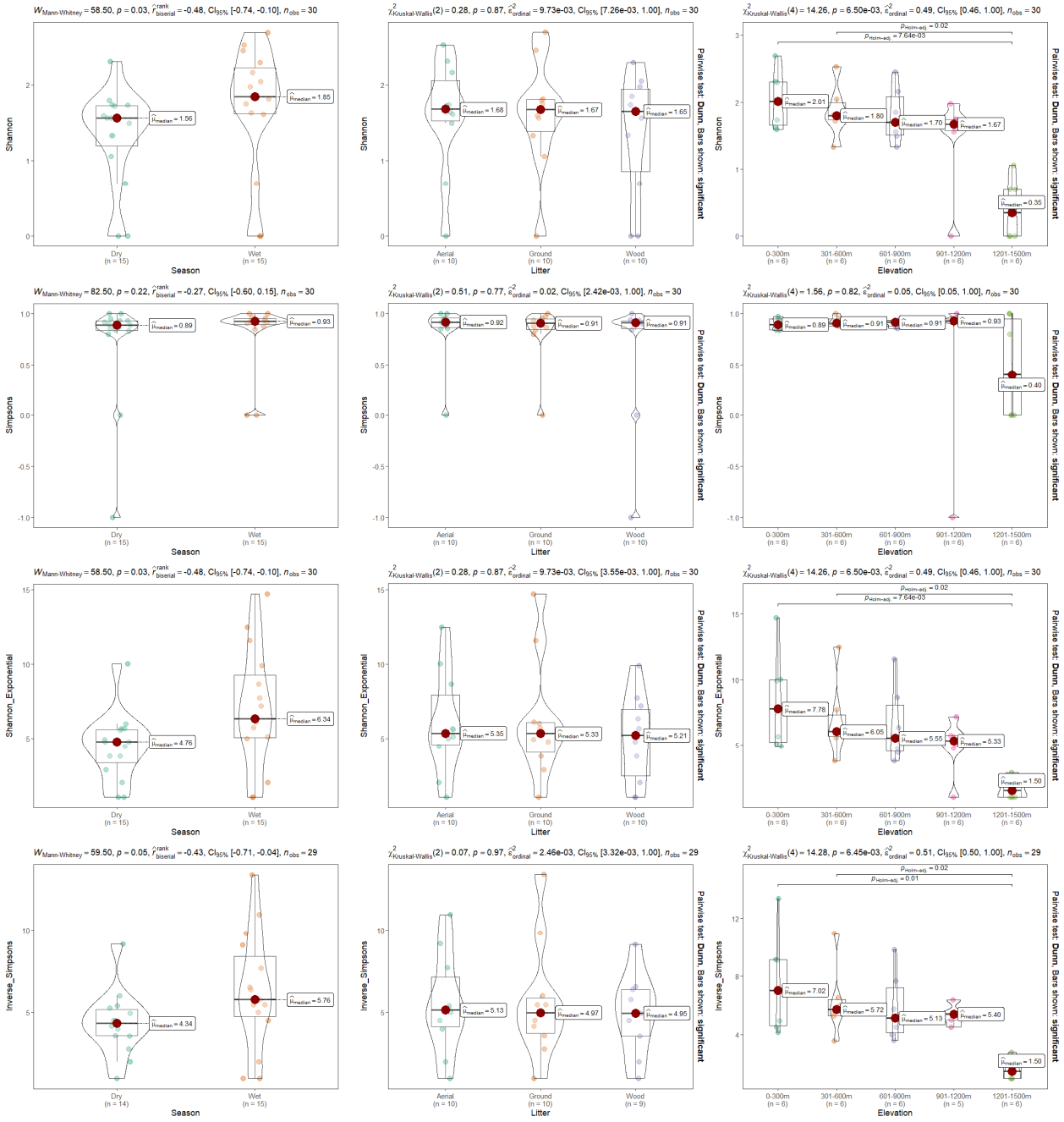

Figure 4. Alpha-diversity violin plots showing the comparison of four different diversity indices (Shannon's index; Simpson's index; Shannon Exponential; Inverse Simpson) in relation to substrate type (**left column**), season (**middle column**), and elevational range (**right column**).

For the elevational gradients, Shannon's index (Kruskal–Wallis test) showed a significant difference ($p < 0.05$) across the five elevational gradients with effect size as strong ($\varepsilon^2_{\text{ordinal}} = 0.49$). Pairwise comparison revealed a significant difference (p Holm-adj = 0.02;

7.64×10^{-3}) between elevation one (0–300 masl) vs. elevation four (901–1200 masl) and elevation five (1201–1500 masl). The median declines as the elevation increases from 2.01 (elevation one) to 1.70 (elevation four) and sharply drops to 0.35 at the highest elevation (1201–1500 m). In the Shannon Exponential index (Hill N1), similar results were obtained with a significant difference ($p < 0.05$) still shown. The values of the median for species richness declined gradually from 7.78 (elevation one—0–300 masl) to 5.55 (elevation three—901–1200 masl) and further to 1.50 at elevation five (1201–1500 masl). However, no significant difference ($p > 0.05$) was found in the Simpson's index across the five elevational gradients, which indicates evenness of species distribution relatively across the elevations, with effect size as negligible ($\varepsilon^2_{\text{ordinal}} = 0.05$). The median values remained consistent across the lower elevations (D = 0.89–0.91), with a notable decrease at the highest elevation (1201–1500 m, $\hat{\mu} = 0.40$), although not significant. The Inverse Simpson index, instead, revealed a significant difference across the elevations with a strong effect size ($\varepsilon^2_{\text{ordinal}} = 0.52$). A pairwise comparison significantly revealed differences (p Holm-adj = 0.01; 0.02), particularly between elevation one (0–300 masl) vs. elevation four (901–1200 masl) and elevation five (1201–1500 masl). A downward trend in species diversity ($\hat{\mu} = 7.02$–1.50) was observed from elevation one (0–300 masl) to elevation five (1201–1500 masl).

The observed decreasing trends in Shannon's index and the Shannon Exponential index (Hill N1) with respect to elevation indicate a reduction in species richness and diversity as elevation increases. The higher elevations are characterized by fewer species and a more uneven distribution of individuals, likely due to harsher environmental conditions, such as prolonged moisture exposure and changes in habitat setting, as indicated by reduced resource availability. The lack of significant differences in Simpson's index across elevations suggests that while species richness declines with elevation, the evenness of species distribution remains relatively constant, with a few dominant species at all elevations (*A. cinerea*, *D. hemisphaericum*, and *D. squamulosum*). However, the strong decline observed in the Inverse Simpson index further supports the hypothesis that species diversity becomes more constrained at higher elevations, where only a few species thrive, while the majority of species are absent or rare.

With reference to substrate types, under the Kruskal–Wallis test, there are no statistically significant differences ($p > 0.05$) in Shannon's index and Shannon Exponential index (Hill N1), with similar median values across all the substrate types—aerial litter, ground litter, and wood—and effect size ($\varepsilon^2_{\text{ordinal}} = 0.01$), indicating minimal impact on the diversity. Simpson's index confirmed no significant differences ($p > 0.05$) were observed across the substrate types, with a similar minute effect size ($\varepsilon^2_{\text{ordinal}} = 0.02$). Alternatively, Inverse Simpson (Hill N2), with similar median values, also revealed no significant differences ($p > 0.05$) in substrate types. These results suggest that substrate type, whether aerial litter, ground litter, or wood, did not have a strong influence on species diversity in terms of richness, evenness, or dominance, as all diversity indices showed a very small effect size, suggesting that other ecological factors may have a greater impact on species diversity in this system.

The analysis of beta-diversity revealed the degree of species turnover and community difference between seasonal collections at different elevational gradients from substrate types. The non-metric multidimensional scaling (NMDS) plot (Figure 5) shows the clustering of species based on seasonal collection (dry vs. wet), the stress value (k = 2) of 0.154 indicates a reasonably good fit for ordination, and PERMANOVA analysis shows that the variation ($R^2 = 0.0429$; F-stat = 1.2548) of species composition between the two seasons was not statistically significant ($p > 0.05$), suggesting that season alone is not a strong predictor for species composition. In terms of elevational gradient, the spread of communities overlaps across the gradients, indicating that the variation in community

structure is explained by elevation (R^2 = 0.209; F-stat = 1.6549). Several species are shared across different elevations, yet there are distinct community compositions at certain elevations (0–300 masl and 601–900 masl), which implies that elevation is a significant predictor in shaping community structure dynamics ($p < 0.05$). With the effect of substrate types on community differences, there is a considerable overlap, showing that approximately 9.5% of the variance in community structure (R^2 = 0.095; F-stat = 1.4156) is based on substrate; however, it was statistically insignificant ($p > 0.05$), which implies that species may not have strong substrate preferences or could be generalists across different microhabitats, thus having minimal influence on species composition. The NMDS stress plot illustrated a high non-metric fit (R^2 = 0.976), which accurately signifies the configuration of NMDS that reflects the relationships within the species community structure. A high correspondence of an NMDS ordination implies greater capture of the variation in species composition, validating the findings mentioned above.

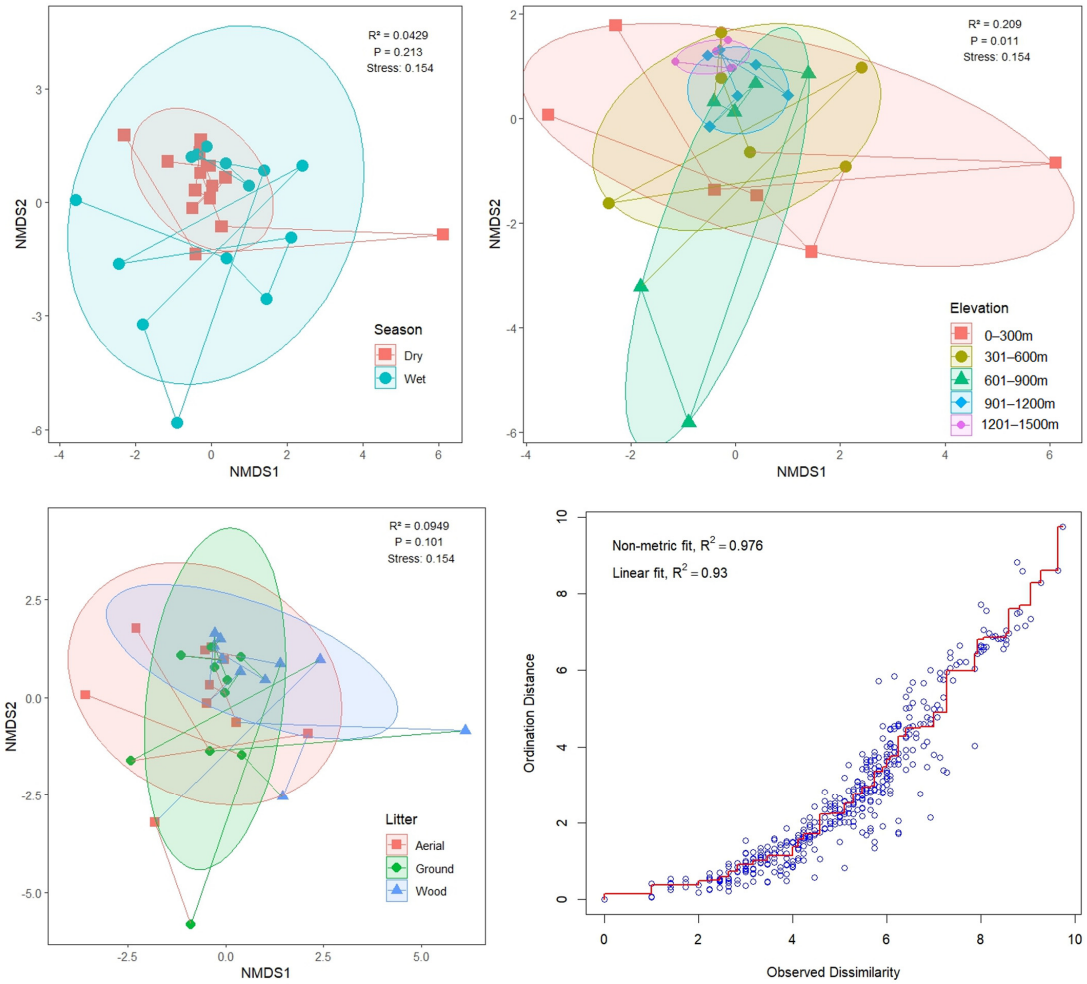

Figure 5. Non-metric multidimensional scaling (NMDS) ordination plot of myxomycetes species composition across different seasons, substrate types, and elevational ranges; ellipses represent 95% confidence intervals around per group; stress plot showing the relationship between observed dissimilarities and ordination distances from the NMDS analysis (k = 2); red line shows a smoothed fit, non-metric fit (R^2 = 0.976), and linear fit (R^2 = 0.93).

The distance metrics (Figure 6), as visualized in dendrograms on hierarchical species communities clustering across different elevations, revealed patterns of similarity and dissimilarity groupings as influenced by seasonal collection and substrate types. The hierarchical clustering of species across elevations using Bray–Curtis and Jaccard distances

revealed corroborative patterns in the community composition of myxomycetes across the elevational gradient. The Bray–Curtis dissimilarity measured the species composition, showing a greater dissimilarity between lower and higher elevations, with elevation four (901–1200 masl) and elevation five (1201–1500 masl) clustering closely, while at lower elevations—elevation one (0–300 masl)—the degree of dissimilarity decreases, then elevation two (301–600 masl) and elevation three (601–900 masl) show a more gradual shift in dissimilarity. This pattern suggests that species composition in higher elevations is more distinct from lower elevations, with a greater turnover of species across the elevational gradient, which means species present at higher elevations are more distinct from those at lower elevations, with fewer species shared between them. In contrast, the Jaccard similarity index indicated a complementary structure, where higher elevations [four (901–1200 masl) and five (1201–1500 masl)] are clustered closely, and lower elevations form a major cluster—with elevation two (301–600 masl) and elevation three (601–900 masl) being more similar. Elevation one (0–300 masl) and elevation two (301–600 masl) showed higher similarity to each other, contrasting with the Bray–Curtis result and indicating that species presence or absence shapes the structuring of community composition at different elevations rather than abundance. The correlation between the dendrograms and the original distance matrices (Cophenetic Correlation Coefficients) was high for Bray–Curtis (0.9678) and moderately good for Jaccard (0.8226), indicating that the clustering patterns accurately represented the relationships in species composition across elevations. The Monte-Carlo simulation was conducted to assess how the observed species richness pattern aligns with two theoretical models across the elevational gradient. The simulation results indicate a strong correlation between the observed species richness data and the model, where species richness declines with increasing elevation, creating a monotonic relationship across the elevational gradient. This is opposed to the mid-domain hypothesis, which predicts a unimodal distribution of species richness peaking at mid-elevations and did not align as well with the observed data.

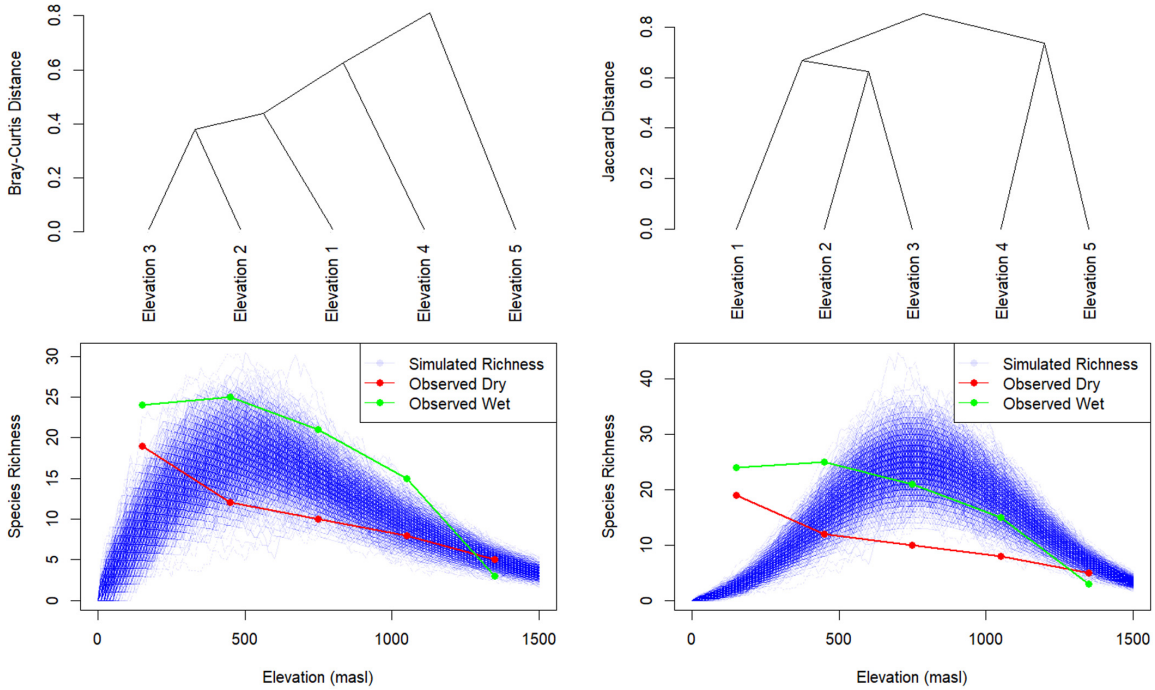

Figure 6. Neighbor-joining clustering tree based on species composition (species and abundances) utilizing Bray–Curtis dissimilarity (CCC = 0.9678) and Jaccard similarity distances (CCC = 0.8226); Monte-Carlo plot simulating the hypotheses—species decreases as elevation increases—and mid-domain hypothesis.

4. Discussion

The present study evaluates the diversity and distribution of myxomycetes along five elevational gradients in the Mount Calavite Wildlife Sanctuary, Occidental Mindoro, collected at different seasons from various substrate types. Previously, the study of Dagamac et al. [21] attempted to conduct a similar study design; however, the highest accessible site for the chosen mountain—Mount Arayat National Park (MANP)—reaches only up to approximately 800 masl, which, in comparison, can only be still at a midline level of the mountain. Therefore, to definitively determine the increasing trend of the myxomycete biogeographical pattern in terms of elevation in the Philippines, a comparable tropical protected mountain, MCWS, has been chosen to test the hypothesis that the diversity of morphologically determinable myxomycetes decreases as the elevation along a mountain increases. Although this study provided a snapshot of the community structure and composition of myxomycetes to prove an evident ecological pattern, certain aspects could be further refined. While seasonal comparisons were made between dry and wet seasons, a longer temporal duration would offer a deeper understanding in terms of the interannual variability of community dynamics. Likewise, further exploration of the study across more diverse spatial scales would capture a broader representative range by which variable microhabitats are reflected. Multifactorial environmental variables would depict a more comprehensive picture of the ecological forces shaping the community structure that can be simply overlooked, such as, without being confined to soil properties, microclimatic factors (e.g., temperature, humidity, precipitation, and canopy cover) and biotic interactions (e.g., type and classification of habitat).

4.1. The Current Finding Corroborates Neotropical Observations

The productivity of the MCs in this study (66%) was greater than the previous investigation of [40] in MANP and was comparable to the study done in Costa Rica (69%), a tropical country but in the Neotropics, that tested the influence of elevation on myxomycetes' diversity as well [54]. Furthermore, the same species occurrence in Costa Rica was observed consistently throughout the elevational gradients—*Didymium squamulosum*. Likewise, *Arcyria cinerea* [which is no surprise, as they are considered generalist and common [55], and *Perichaena depressa* [common and abundant based on previous studies of [56,57]] were also observed consistently. Apart from that, occurrences of *C. nigra*, *D. difforme*, *P. compressum*, *P. bivalve*, and *S. fusca* were observed in high-elevation myxomycetes assemblages that resembled those in the northern Neotropics [58]. The species records identified in this study exhibited similarities to the species reported in previous studies conducted in the neighboring vicinity of MCWS, such as in Lubang Island with 45 species [20], Puerto Galera with 42 species [59], Mt. Malasimbo with 36 species, and Mt. Siburan with 49 species [60]. This now shows that the diversity among closely situated smaller island groups of Mindoro is much more similar than different. A corresponding study carried out in a tropical moist forest in Yasuní National Park, Ecuador [47], where typical myxomycetes were known, was recorded for the first time in the Philippines—*D. collumela-cavum*. Most species occurrences in this study fall into singletons and doubletons, which is unsurprising, as prior surveys have reported the same circumstances in either the Neotropics or the Paleotropic regions [49]. Still, the Neotropical region has the most thorough investigations on tropical myxomycetes compared to the Paleotropic regions, if not around the world [61]; however, research in the Paleotropics is gradually gaining momentum.

4.2. Is the Pattern of Diversity of Myxomycetes in Elevational Gradient a Rule of Thumb?

Elevation is a crucial environmental component that affects the vertical distribution of myxomycete species, resulting in varying levels of abundance and diversity at different elevations [15]. The long-withstanding traditional concept that persists on myxomycete

diversity—as the elevation increases, the species richness decreases [29,30]—holds true for Neotropical regions [49,62], except for corticolous species [63]. However, recent studies have already explored whether this hypothesis remains consistent in the southeast Paleotropics. Investigations conducted in Southern Vietnam, which analyzed various habitats, revealed a consistent trend that supported this hypothesis [12,64].

The results of this study seem to support this ecological trend, which suggests an inverse relationship between species richness and elevation. Elevation one (0–300 masl) was observed to have the highest species diversity among the elevational ranges, followed by elevation two (301–600 masl), up to the highest peak (1201–1500 masl). In addition, based on taxonomic diversity, more taxonomically diverse assemblages were observed at lower elevations (0–900 masl) than at higher elevations (901–1500 masl). The significant decrease in diversity indices with elevation suggests that high-elevation ecosystems may be more vulnerable to environmental changes, with reduced species richness and potentially greater susceptibility to climate change impacts. Furthermore, the NMDS findings emphasize the significance of elevation in shaping the distribution of species, yet the majority of the variability (R^2 = 79.05%) remains unexplained, suggesting that other environmental factors or biotic interactions are contributing to the observed patterns in species composition. Such dissimilarities between myxomycetes communities are associated with differences in vegetation types [65]. Since the MCWS has two distinct forest formations, it can be linked to the topography, habitat structure, and type of floristic assemblages. The MCWS has diverse vegetation, ranging from grassland to second-growth forests at different points of recovery, and it reflects past human and natural disturbances [32]; for example, floristic composition dictates the distribution of myxomycetes (but is not limited to), and the resource availability that builds up microhabitats establishes the most determining factor for species distribution [66]. This is something that studies should be able to adapt, as even countries with extensive studies have barely examined this, and they should consider concluding the degree of their influence on species assemblages [55]. Furthermore, the difference in moisture levels across the elevations and how this is regulated within a forest directly influences the growth of myxomycetes (excess moisture impedes their growth [67]).

Perhaps tropical regions with distinctive environmental pressures [68] at higher elevations could drive distinct species assemblages as microclimatic conditions fluctuate over time. Yet, no distinct species composition was observed at higher elevations. Interestingly, plasmodia or sclerotia were most commonly observed in the MCs found at higher elevations. The persistent moisture at higher altitudes may hinder the growth and development of myxomycetes; in heavy precipitation, their vegetative cells are displaced, and, in turn, fructification and development are disrupted [69,70]. It was previously implied that at the moisture levels in the tropical regions, with respect to increasing elevation, the species richness decreases; the same goes for the positive productivity of MCs [71].

4.3. Microclimate Directly Affects Fructification

The classification of a habitat with its parameters and microclimatic conditions therein are the key factors that determine the diversity and distribution of myxomycetes. These were the primary focus of synecological studies in defining species compositions. Any attempt to build a more comprehensive ecology of myxomycetes in terrestrial ecosystems would benefit from investigating the impact of seasonality [72]. Seasonality maintains its influence in shaping species composition, as each season brings forth a set of motions in temperature, humidity, and nutrient availability, creating a dynamic feedback loop that constantly affects an ecosystem. The species composition of myxomycetes based on previous investigations can be unique in each microhabitat, with species thriving in specific environmental conditions [28]. The wet seasonal collection exhibited greater diversity and

abundance compared to the dry season, with a wider composition of myxomycetes species in the NMDS analysis. The microclimate affecting decomposition in forest ecosystems depends on the various aspects of litter diversity, causing deviations in species richness, functional communities and composition, relative abundances, and functional dissimilarity of litter species [73]. The seasonal differences (wet and dry) in the tropics by which the microbial prey (e.g., bacteria and fungi communities) thrive tend to cause myxomycetes to flourish as well [15,74]. And if the organic matter that comes from dead plant tissues, after being decomposed by fungi and bacteria, is consumed by detritus feeders such as myxomycetes in their trophic stage, nutrients are released, and the decay rate and activity are regulated [75]. Since the myxomycetes feeding stage is at the plasmodial form, wet conditions permit their development [76]. Decreased litter species diversity leads to a reduction in the rate of decomposition [77]. Hence, seasonal changes, particularly during the wet season, must facilitate greater species diversity and abundance. Such shifts in environmental conditions and other variables impact the functional traits of the reproductive strategies of myxomycetes in response to compensation for the resources that are available [78]. Given the significant impact of rainfall and moisture on tropical forests, it is necessary to know how local humidity is affected by changes in season and how this affects the diversity and distribution of myxomycetes [79].

Accordingly, the type of season can be significantly influenced by the substrate on which they grow. The availability of nutrients, moisture, and abundance in a substrate in the establishment of an overlying litter layer, decaying wood, tree bark, or other substrates associated with different decaying plant materials can dictate their growth in that specific environment [80]. The community structure in both seasons, as aligned with the Mandelbrot model, indicated a hierarchical organization of dominance, as shifts from the wet season can favor species to predominate that thrive best at increased moisture and nutrient availability, leading to higher abundance. Then, by the dry season, the changes in environmental conditions may favor different species that are better adapted to drier conditions. The distribution of myxomycetes species emerges in dominance depending on the prevailing conditions. There is a general concurrence that higher dominance and diversity values favor aerial litter collected at dryer periods, as a common pattern in myxomycete surveys worldwide [54]. This pattern is evident in the wet tropics, where aerial microhabitats exhibit a tendency to dry out more rapidly after rainfall events than in-ground litter [71]. Although there was more abundance of species in ground litter, it had lower diversity compared to wood. The aerial litter, nonetheless, displayed a greater degree of species diversity among the three substrates. While the findings exhibited no significance in terms of diversity across the different substrate types, notably, species abundance was relatively spread out. The higher species richness observed in leaf litter in tropical forests can be related to its strong indication of chemical heterogeneity, which is characterized by complex structure and unpredictable patterns of microclimatic conditions [81]. Perhaps the floral heterogeneity in each habitat presents a confounding factor that influences the diversity of species. As such, differences in composition may have adapted to thrive in specific microclimatic niches. Limiting factors continue to persist, as fluctuations in temperature and moisture availability can impact their presence. However, differences in tolerance to these variables per species continue to adapt over time [82].

4.4. Cautious Interpretation of Myxomycete Ecology Due to Hidden Diversity

With recent advancements in technological identifications for species, synecological studies for myxomycetes continue to use the morphological species concept [71]. Traditionally, this concept has mostly been widely used in protists, whereby the occurrence of speciation leads to the manifestation in morphology, although this is inconsistent [83]. Since

the reliance on morphology, indistinguishable life forms of myxomycetes (e.g., amoeba-flagellate cells or plasmodia) cannot be used for identification. Hence, the only way to identify them is the presence of mature fruiting bodies [84]. The Philippines has experienced a significant increase in myxomycetes research over the years; however, the application of molecular methods is still in its infancy. Notwithstanding the progression in investigating biodiversity in new habitats while the discipline still heavily depends on conventional morphological identification, this could impede more comprehensive understanding in terms of their taxonomy. Limitations arise whenever morphospecies exhibit phenotypic variations, which can lead to misidentification and cryptic species existence, which is an even more challenging dilemma to handle. Myxomycetes species are identified based on the established characteristics of their fruiting bodies, which typically undergo evolutionary changes over a series of recombinant traits that were previously distinguished features from other taxa, including simultaneous changes in their internal structure [85,86]. For ecological studies that seek to understand the diversity and distribution of myxomycetes, relying on such a concept could underestimate the hidden diversity if one lacks sufficient expertise in species identification or if expert guidance is lacking. Emerging studies incorporating molecular methods for such ecological studies, as highlighted from the review by Buisan and Dagamac [87], indicate that the myxomycete diversity currently known to the Southeast Asian Paleotropics seems to be merely the proverbial phrase the "tip of the iceberg".

Developing research has shown that the traditional morphological approach probably depends merely on the fructification of the myxomycetes, which also heavily relies on many complex and dynamic environmental factors. Favorable conditions in the microclimate can induce successful fruiting, hence allowing species' growth to be highly random by chance. Current research on slime molds discovered in soil provides evidence of amoebal stages that remained in the soil and declined to fruit [88,89]. More recently, the cosmopolitan species—*H. serpula* and *Lycogala epidendrum*—emerged as compelling cases in illustrating cryptic speciation that exhibited morphological and genetic intraspecific variation, respectively [90,91]. In addition, the spore size of myxomycetes is regarded as a valuable taxonomic character that can exhibit phenotypic plasticity, as revealed in the study of Woyzichovski et al. [92] using *Physarum albescens* as a model organism despite strong genetic stability. In these cases, molecular techniques can provide more reliable species identification and distribution, particularly in instances involving phenotypic plasticity or cryptic species, as elucidated by DNA barcoding [93]. A common trend that is now applied is the coupling of morphological and molecular identification and assignment to analyze the complete picture of the diversity of myxomycetes in a certain locality [94–96]. The sequences produced by molecular techniques hold significance in capturing biodiversity by utilizing operational taxonomic units (OTUs) when associated with metadata for bioinformatic analyses [97].

The scarce funding for Southeast Asia (SEA) research limits the broad significance and impact of scientific discoveries [98]. Equipment needed for molecular analysis does not always come at a low cost, and the reagents required for an operation can also be quite expensive, with limited shelf-life and storage constraints. The difficulty of budgetary procurement and the accessibility of specialized facility space for conducting such analyses can also pose challenges. For instance, DNA kits are relatively expensive, as companies revise protocols requiring additional steps to process [99]. If such constraints for molecular technologies are not addressed, then these necessitate collaborations from first-world countries with richly resourced institutions that can provide opportunities for researchers in SEA to perform molecular analysis and techniques in their respective fields [100]. Effective science communication represents the success of well-defined research; if not translated into the stringent framework and legal regulatory actions as restricted by limited funding [101],

there would be a disconnect between scientific findings and real-world impact. These future directives in understanding most ecological studies should become a pre-requisite, especially in long-term investigations of myxomycete diversity in Southeast Asia. Nevertheless, despite the lack of funding opportunities for developing countries to fully elucidate the molecular component of diversity studies for myxomycetes, this classical morphological approach resulting from our study seems to conform to the current knowledge about elevational patterns in the tropics, galvanizing the hypothesis that elevation affects myxomycete diversity.

5. Conclusions

The investigation conducted in this study explored the richness and abundance of myxomycetes across elevational gradients that were collected on two seasonal collections from different substrate types. The results underscore elevation as the primary driver influencing myxomycete community structure, with species richness and diversity metrics revealing significant decline at higher elevations. The lack of significant difference across different seasons and various substrate types could indicate that they are not the principal factors for species diversity and abundance in this setting, or perhaps that the species observed were generalists, yet it could also be rather the interplay of elevation, seasonality, and other environmental parameters in shaping a microhabitat. As for the premise that higher elevations should foster higher species diversity due to the presumed minimal disturbances, the result of this study aligns with the specific ecological predictions observed in the Neotropical regions that species richness decreases as elevation increases. The species composition of myxomycetes at low-mid elevations can exhibit that an ecosystem is rich in biodiversity and is an important indicator of environmental conditions. Likewise, ecosystems at low-mid elevations could offer the optimal conditions for myxomycetes, as they display the greatest species richness. While the use of traditional methods has provided valuable insights, it still stipulates the integration of molecular tools and techniques to enhance species resolution and reveal cryptic diversity. Determinant abiotic factors should also be considered for future investigation, such as more microclimatic conditions and substrate characteristics that can aid in the evaluation of their influences on myxomycete communities. Increasing the number of samples and implementing year-round monitoring would also help capture temporal variations and provide a more comprehensive ecological perspective.

The existence of myxomycetes might not be prominent to society, including the indigenous people (IP) inhabiting the MCWS, but the significance they bring in maintaining the delicate balance of the ecosystem is undeniable. Given that the distribution and diversity of myxomycetes are mostly determined by microclimatic conditions, such as temperature, moisture, pH, substrate, and elevation, any drastic shifts in these parameters or disturbances to the habitats have the potential to affect the species assemblages, which are certainly influenced by rapid climate change occurring globally. There is ecological proof that this study may not just serve as a valuable contribution to the field of myxomycete ecology but may also provide an important insight for conservation efforts in the sanctuary. The integration of ecological hypotheses further strengthens the study to ensure sustainable land use management and conflict resolution discussions between the IPs. Future ecosystem management, as regulated by local government units, should consider biodiversity in implementing conservation strategies to ensure that the ecosystems at stake are well protected and managed effectively.

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