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Influence of soil properties on tree species diversity of the base of Mt. Musuan, Bukidnon, Philippines

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Abstract

The study was conducted to determine the influence of soil properties on the tree species diversity of the base of Mt. Musuan, Bukidnon, Philippines. Ten plots with a size of 100m² were established for the assessment of trees. Soil samples were taken from each plot at 0-15cm depth to measure chemical properties. For vegetation analysis, Shannon-Weiner diversity index, Margalef's index, and species evenness were used. Soil pH, organic carbon (OC), organic matter (OM), nitrogen (N), phosphorus (P), and potassium (K) were determined through soil analysis. The relationship between soil chemical properties and tree parameters were estimated using correlation and multiple linear regression analysis. Significant correlation among soil chemical properties was observed. Moreover, results of the study showed that edaphic factors have no significant effect on tree species diversity.

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Introduction

The diversity of tree species is a fundamental aspect of tropical forest biodiversity (Evariste *et al.*, 2010; Tchouto *et al.*, 2016) and influenced by stand structure, species composition, climatic conditions, and geomorphology (Naidu & Kumar, 2016). Globally, tropical forests account for not more than 52% of the total world's biodiversity (Moutsambote *et al.*, 2016) which are significant for carbon sequestration and climate regulation. Variations in the structure of tropical forests are influenced by the heterogeneity of soil characteristics and nutrient cycling (Fujii *et al.*, 2018; Peña-Claros *et al.*, 2012).

Generally, plants respond to soil characteristics compared to other soil variables (Sollins, 1998) and could affect the composition and diversity of plants with respect to climatic conditions. Studies on the soil-vegetation relationship on different habitat types and geographic location revealed contrasting results (Abbasi-Kesbi*et al.*, 2017; Chen *et al.*, 2018; Liu *et al.*, 2008; Long *et al.*, 2018; Nadeau & Sullivan, 2015; Pilania & Panchal, 2016; Stark & Redente, 1985; Wan *et al.*, 2019; Xue *et al.*, 2019; Zheng *et al.*, 2017). In the tropical forest, Nadeau & Sullivan (2015) reported that tree species richness is inversely related to soil fertility while Amani (2018) reported that variations in soils did not affect plant parameters.

Understanding the relationship between soil properties and species diversity is crucial in ecosystem management (Abbasi-Kesbi *et al.*, 2017; Wan *et al.*, 2019). The aim of the present study is to determine the influence of soil chemical properties on tree species diversity at the base of Mt. Musuan, Bukidnon, Philippines.

Materials and methods

Study Site

The study was conducted in the base of Mt. Musuan Botanical and Zoological Garden, Bukidnon, Philippines (Fig. 1). Geographically, it lies between 7°52' 56.82" N and 125°3' 48.20" E. The general climatic condition of the study site is classified as Type III based on the modified Corona Classification of Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) wherein seasons are not very well pronounced, with a dry season from November to April and wet during the rest of the year.

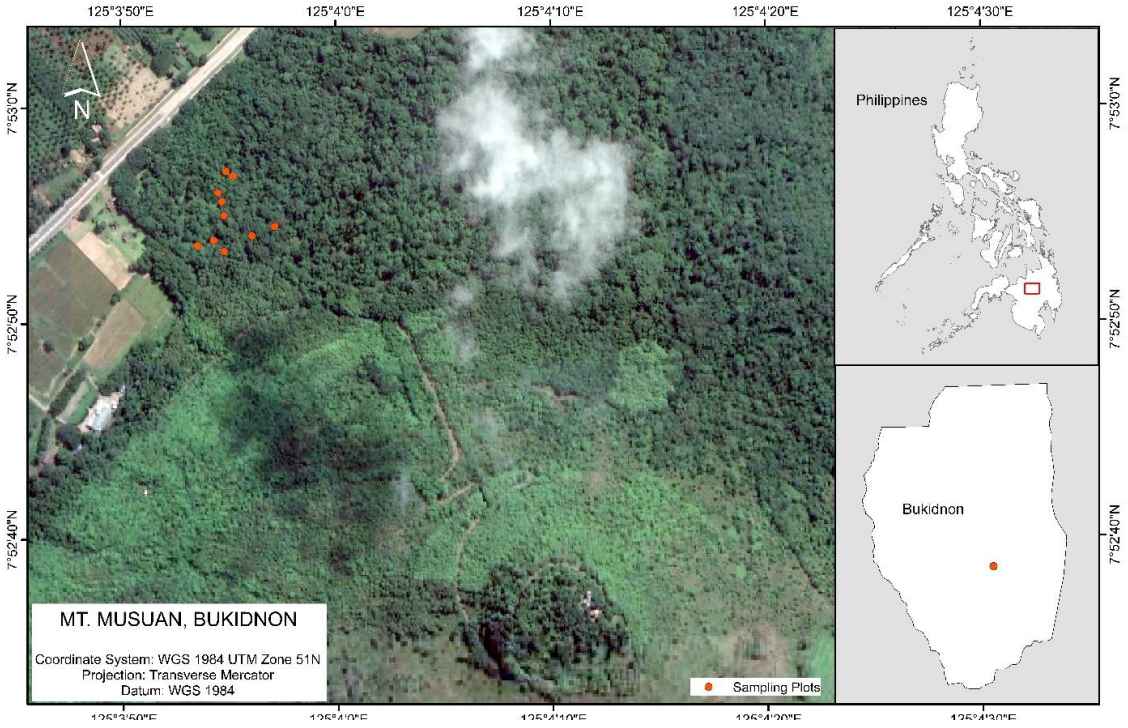

Fig. 1. Location of the study.

Sampling Plots Establishment and Tree Measurement

Ten 10 m x 10 m sampling plots were established randomly at the base of Mt. Musuan Botanical and Zoological Garden. Each sampling plots were geotagged using a GPS receiver. All trees with at least 5cm in diameter breast height (DBH) found in each plot were measured using tree caliper.

Tree Identification and Assessment Conservation Status

Tree species were identified using available floras and monographs. Specimen collection was also done for verification. The conservation status of the species was determined based on the classification by the Department of Environment and Natural Resources (DENR) Administrative Order No. 2017-11 and the International Union for Conservation of Nature (IUCN) red list.

Soil Collection and Analysis

Soil samples were collected in each sampling plot at 0-15cm in depth. Two hundred fifty grams of dry soil samples were placed in a polythene bag and brought to the Bureau of Soils Region IX to analyze soil pH, OM, OC, N, P, and K content. Soil pH was analyzed using a potentiometric method, Walkley Black method for OC, Olsen method for N, cold H_2O extraction method for K, and organic matter and N were determined by computation.

Statistical Analysis

Tree species diversity indices were determined by using Paleontological Statistics 4.02 (PAST) software. Pearson's Correlation and Multiple Linear Regression Analysis were performed by using Statistical Tool for Agricultural Research 2.0.1 (STAR) software to determine the effect of soil chemical properties on the tree species diversity.

Results and discussion

Tree Species Composition and Diversity

A total of 21 trees species were recorded at the base of Mt. Musuan (Table 1). The species were categorized in 20 genera and 12 families with the most number species of the trees were the Caesalpinaceae and Rutaceae. White lauan (*Shorea contorta* S. Vidal) from the family of Dipterocarpaceae had the highest number of individuals followed by matang-araw (*Melicope triphylla* (Lam.) Merr.) from the family Rutaceae.

Fig. 2 shows the diversity of trees at the base of Mt. Musuan, Bukidnon. Results show that the diversity and evenness of trees in the area are quite low with the indices of 0.98 and 0.74, respectively. This validates the study of Olpenda *et al*., (2013), that the species diversity of the natural forest is relatively low. This further implies that the area is less stable and could be due to the vegetation structure of the middle and upper portion of the mountain. Tree species richness in the area was fairly less may be due to the presence of other groups of plants which mostly dominates the area as observed.

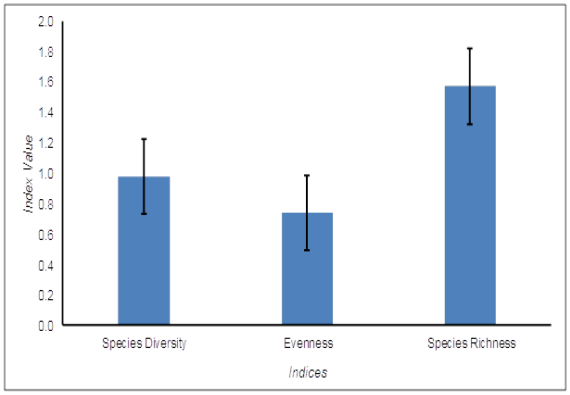

Fig. 2. Diversity indices of trees at the base of Mt. Musuan. Error bars represent the standard error.

Conservation Status

Based on DAO 2017-11, 2 tree species were listed as threatened at the base of Mt. Musuan (Table 1). This includes the vulnerable (V) white lauan (*Shorea contorta* S. Vidal) and the kalomata (*Clausena brevistyla* Oliv) as other threatened species (OTS) while the other remaining species were not yet assessed.

On the other hand, 66.67% of the trees in the area were listed as least concern (LC) and the remaining 33.33% were not evaluated based on IUCN classification. Other significant records include *Cananga odorata* (Lam.) Hook.f. & Thomson, *Polyscias nodosa* (Blume) Seem., *Acacia auriculiformis* Benth., *Acacia mangium* Willd.,

Senna spectabilis (DC.) H.S. Irwin & Barneby, *Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll., *Gmelina arborea* Roxb., *Melia dubia* Cav., *Dysoxylum gaudichaudianum* (A. Juss.) Miq., *Artocarpus blancoi* (Elmer) Merr., *Ficus variegata* Blume, and *Harpullia arborea* (Blanco) Radlk.

Table 1. Species richness and composition of trees at the base of Mt. Musuan.

Taxa			Conservation Status	
Family/Common Name	Scientific Name	No. of individuals	DAO 2017-11	IUCN
Annonaceae				
Ilang-ilang	*Cananga odorata* (Lam.) Hook.f. & Thomson	1	UA	LC
Araliaceae				
Malapapaya	*Polyscias nodosa* (Blume) Seem.	2	UA	LC
Bignoniaceae				
Pingka-pangkahan	*Oroxylum indicum* (L.) Kurz	2	UA	UA
Caesalpiniaceae				
Acacia	*Acacia auriculiformis* Benth.	1	UA	LC
Manguim	*Acacia mangium* Willd.	2	UA	LC
Anchoan dilaw	*Senna spectabilis* (DC.) H.S. Irwin & Barneby	6	UA	LC
Dipterocarpaceae				
White Lauan	*Shorea contorta* S. Vidal	10	VU	LC
Euphorbiaceae				
Hinlaumo	*Mallotus mollissimus* (Geiseler) Airy Shaw	1	UA	LC
Alim	*Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll.	3	UA	LC
Lamiaceae				
Gmelina	*Gmelina arborea* Roxb.	5	UA	LC
Meliaceae				
Bagalunga	*Melia dubia* Cav.	1	UA	LC
Igyo	*Dysoxylum gaudichaudianum* (A. Juss.) Miq.	3	UA	LC
Moraceae				
Antipolo	*Artocarpus blancoi* (Elmer) Merr.	5	UA	LC
Tangisang-bayawak	*Ficus variegata* Blume	1	UA	LC
Rutaceae				
Kalomata	*Clausena brevistyla* Oliv.	1	OTS	UA
Matang-araw	*Melicope triphylla* (Lam.) Merr.	8	UA	UA
Tulibas-tilos	*Micromelum minutum* Wight & Arn.	7	UA	UA
Sapindaceae				
Alahan	*Guioa koelreuteria* (Blanco) Merr.	1	UA	UA
Uas	*Harpullia arborea* (Blanco) Radlk.	1	UA	LC
Verbenaceae				
Teak	*Tectona grandis* L.f.	4	UA	UA
Bongoog	*Vitex glabrata* R.Br.	1	UA	LC
	Total Individuals	66		
	Total Species	21		

E-Endangered; VU=Vulnerable; OTS=Other Threatened Species; LC=Least Concern; UA=Unassessed

Influence of Soil Chemical Properties on Tree Species Diversity

The soil collected at 0-15cm in depth showed significant correlations between soil chemical properties (Table 2). The results showed a highly significant relationship between OC and OM, % N, and available P. Similarly, a very high significant relationship between OM and % N, and available P, while significant relationship between % N and P was observed. On the other hand, available K and pH were found to be no significant relationship to OC, OM, % N, and available K.

Table 2. Correlation matrix of soil chemical properties.

	pH	% OC	% OM	% N	P (ppm)	K (ppm)
pH	-					
% OC	0.324	-				
% OM	0.320	0.100**	-			
% N	0.300	0.997**	0.997**	-		
P (ppm)	0.091	0.784**	0.7834**	0.760*	-	
K (ppm)	0.608	0.501	0.499	0.498	0.270	-

*=significant at 5%; **=significant at 1%

The change in species composition and diversity is attributed to the variation of soil properties (Liu *et al.*, 2008). Xue *et al.* (2019) reported that the effect of soil on the diversity of plant species depends on the variations of nutrients contents in the soil. Masoud *et al.*, (2015) observed that the amount of OC and K in the first soil depth had a positive effect on the species diversity index. One of the significant variables that must be considered to understand tree diversity is the soil pH (Amani, 2018).

In our results, soil chemical properties showed no significant correlations between tree parameters and soil chemical properties (Table 3). These results further suggest that soil factors did not influence tree species diversity in tropical forests (Table 4). Similar results were also observed by (Abbasi-Kesbi *et al.*, 2017; Amani, 2018). Albeit no significant differences were found between soil chemical properties and tree species richness, diversity, and evenness, there may be other fundamental processes and attributes of the area that entailed further studies (Amani, 2018).

Table 3. Correlation between soil chemical properties and species diversity, evenness, and richness.

Soil Chemical Properties	Species Diversity	Species Evenness	Species Richness
pH	0.359^{ns}	0.059^{ns}	0.308^{ns}
% OC	-0.022^{ns}	0.326^{ns}	0.004^{ns}
% OM	-0.019^{ns}	0.322^{ns}	0.008^{ns}
% N	-0.027^{ns}	0.337^{ns}	0.004^{ns}
P (ppm)	-0.076^{ns}	0.243^{ns}	-0.143^{ns}
K (ppm)	-0.091^{ns}	0.289^{ns}	-0.155^{ns}

**=significant at 5%; **=significant at 1%; ns=not significant*

Table 4. Multiple linear regression analysis.

Soil Chemical Properties	Species Diversity	Species Evenness	Species Richness
pH	ns	ns	ns
% OC	ns	ns	ns
% OM	ns	ns	ns
% N	ns	ns	ns
P (ppm)	ns	ns	ns
K (ppm)	ns	ns	ns
R^2	0.63	0.81	0.57

ns=not significant

Conclusion

The diversity of tree species of the base of Mt. Musuan was not influenced by soil chemical properties. On the other hand, the presence of threatened and endemic species such as *Shorea contorta* S. Vidal *and Clausena brevistyla* Oliv. suggests that the ecosystem is a good habitat for both flora and fauna. Thus, monitoring and conservation efforts must be reinforced.

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