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Research Article

DIVERSITY PATTERN OF ANGIOSPERM TREE AND SHRUB ON NATURAL VEGETATION OF COASTAL SANDY REGION IN TRIEU PHONG AND HAI LANG DISTRICTS, QUANG TRI PROVINCE, VIETNAM

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ABSTRACT
In the coastal sandy region in Trieu Phong and Hai Lang districts, 80 species of tree and shrub–of angiosperm were identified. The structure of the assemblages in 3 habitat types and 3 vegetation types were clearly different with 97.68% and 89.89%, respectively. The average species richness and diversity index of the assemblages distributed in different habitat and vegetation types were statistically significant. The average species richness and diversity index was highest in stable dunes (S=10.04 and 1-D=0.78) and closed forest (S=12.05 and 1-D=0.82). The subsequent data were recorded in the sandy wetlands (S=2.35 and 1-D=0.35) and shrubs (S=8.50 and 1-D=0.70), while the lowset was observed in mobile dunes (S=1.00 and 1-D=0.00) and herbaceous vegetation (S=2.08 and 1-D=0.34). The research results have important practical implications for the management and conservation of local vegetation biodiversity.

Keywords: *Angiosperm, Diversity Pattern, Natural Vegetation, Quang Tri, Sandy Area, Tree And Shrub*

INTRODUCTION
Coastal vegetation is dynamic ecosystem influenced by many environmental factors such as wind, tides, sand burial, and other biological factors (Maun, 2009). This is ecosystem of high biodiversity due to the heterogeneity of habitat types (Louisse and van der Meulen, 1991). The formation of sand dunes is associated with the succession of vegetation. The interaction between environmental factors creates different types of habitats (Wiedemann, 1984). The interaction between environmental factors and plants has created many vegetation types which have different species compositions (Avis and Lubke, 1996).
Coastal sand dune vegetation plays an important role in biodiversity in this ecosystem and in human life (Martínez *et al.*, 2001). Vegetation reduces wind speed and prevent sand movement (Levin and Ben-Dor, 2004), protect coastlines, and mitigate the effects of climate change including storms, sea level rise and erosion (Cochard *et al.*, 2008). However, coastal ecosystems are at the risk of major biodiversity loss and are under threat worldwide (Brown and McLachlan, 2002). This is an ecosystem that is particularly sensitive to human activities (Garcia-Lozano *et al.*, 2018). The major human impacts such as urbanization, construction, cultivation, animal husbandry outdoor activities… cause habitat fragmentation as well as loss (Janssen *et al.*, 2016) and reduce the biodiversity (Laurance and Useche, 2009).
The sandy coastal area of Trieu Phong and Hai Lang districts of Quang Tri province currently has very little natural vegetation (Nguyen *et al.*, 2004). Besides the influences of the Vietnam War, human factors also greatly contribute to reducing the area of vegetation in this sensitive ecosystem. This ecosystem is exploited by human, via farming, aquaculture, building houses and making paths leading to fragmented habitats and a reduction in the area of natural vegetation (Nguyen, 2007). Therefore, the sandy soil of Quang Tri province is in danger of serious erosion (Nguyen, *et al.*, 2006-2007), wind being the main factor (*Nguyen, et al.*, 2014). Therefore, it is very necessary to conserve and increase the area of vegetation cover in this area. Studying the diversity patterns of woody and bushy plants in these two areas in Quang Tri province would provide more information as a scientific basis of biodiversity conservation.

MATERIALS AND METHODS

Study side

The study area includes Trieu Phong and Hai Lang districts, Quang Tri province, in central Vietnam. This sandy land has north latitude and east longitude coordinates are 16°54'21.05" - 16°44'34.02", 107°23'17.87" - 107°11'55.68", respectively (figure 1). This study area has a coastline of 27 km. In addition, the relatively flat terrain combined with sandy soil distributed deep inland about 5.16 km (Nguyen *et al.*, 2004) has formed many types of habitats such as stable dune, sandy wetland, mobile dune, and diverse vegetation types including herbaceous vegetation, shrub and closed forest. The study site has a specific tropical monsoon climate with two separate seasons in a year, including the rainy season from August to December and the dry season in the remaining months (Nguyen, 2015). The average rainfall in the wet and dry seasons is 134.6 mm - 747.5 mm and 30.8 mm - 193.8 mm, respectively, while the average temperature of the rainy season and dry season is 21.3 - 28.2 degrees Celsius and 29.3 - 30.6 degrees Celsius, respectively (Quang Tri Statistical Office, 2021).

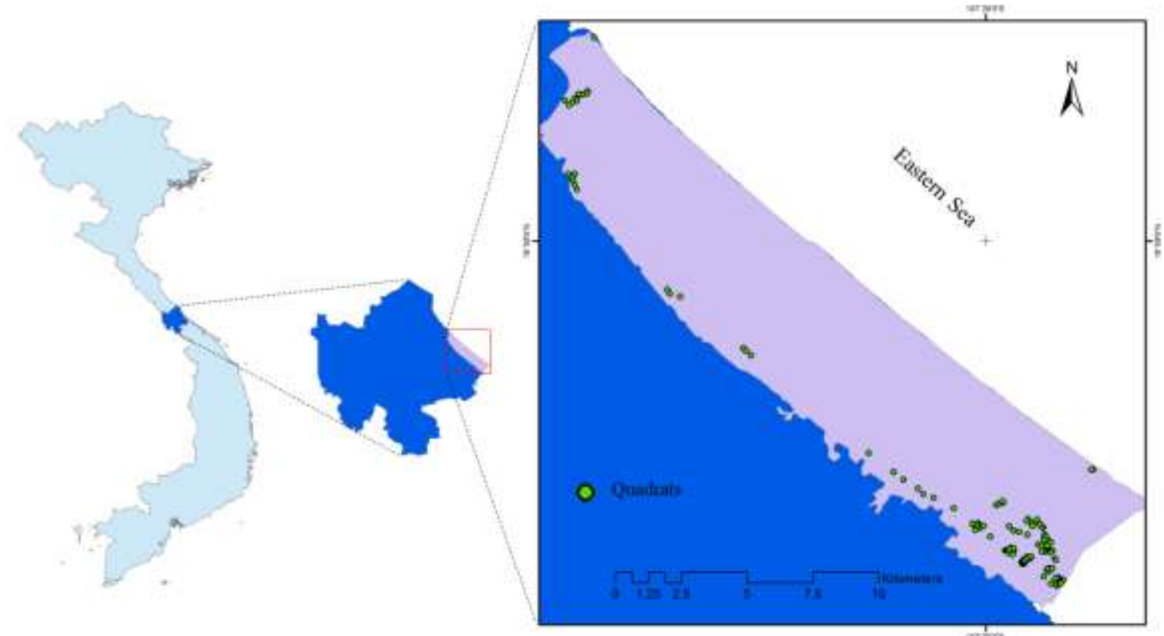

Figure 1: The coastal sandy areas of Trieu Phong and Hai Lang districts, Quang Tri province

Data collection

Data were collected from natural vegetation in three type of habitats (stable dunes, mobile dunes and sandy wetland), and three vegetation types (closed forest, shrubs and herbaceous vegetation) on the coastal sandy area of Trieu Phong and Hai Lang districts. A total of 142 random 10 ×10 m quadrats (de Pádua Teixeira *et al.*, 2011) was conducted. The species composition and number of individuals of tree and shrub which are higher than 0.5 m were collected. The survey period was from March to September 2018.

Data analysis

Permutational multivariate analysis of variance (PERMANOVA) was used to test the hypothesis that communities differ in species composition, abundance between habitats and vegetation types (Anderson, 2001); whereas the SIMPER method was used to determine the total difference between populations as well as the species that contributed the most to that difference (Clarke and Warwick, 1994). Both PERMANOVA and SIMPER used abundant data with Bray-Curtis' dissimilarity index, especially data was not converted. Species richness and Simpson's diversity were also used to evaluate the diversity

patterns across habitats and vegetation types. Analysis of ANOVA/Games-Howell test for Homogeneity of Variances (Lee and Lee, 2018) to compare the mean values of species richness and Simpson's diversity in habitats and vegetation types. Data analysis was performed by PAST v3 software (Hammer *et al.*, 2001).
Nomenclature: Following an Illustrated Flora of Vietnam, vol. 1 to 3 (Pham, 1999-2003) and Flora of Vietnam vol. 1 to 11 (Vietnam Academy of Science and Technology, 2002-2007).

RESULTS AND DISCUSSION

Species composition

A total of 80 species have been identified in 28 families and 64 genera (Table 1). Among them, there are five dominant families in terms of number of species including Myrtaceae consisted of 10 species, followed by Phyllanthaceae (8 species), Lauraceae and Rubiaceae with 7 species each and Myrsinaceae with 5 species. These 5 families account for 46.25% while the remaining 24 families account for 53.75% of the total species. In the total of 64 genera, *Syzygium* genus has the highest diversity with 6 species; other 11 genera contain 2 species in each one, while only 1 species was observed in each of these remaining genus.
The study identified 6 species including *Ilex brevicuspis*, *Ilex cymosa*, *Strychnos polyantha*, *Syzygium odoratum*, *Psydrax umbellata*, *Dodonaea angustifolia* which have not been recorded in previous studies. Myrtaceae, Phyllanthaceae, Lauraceae, Rubiaceae, Myrsinaceae and *Syzygium* were also recorded with a dominant number of species in woody and shrub flora in the sandy coastal area of Gio Linh district, Quang Tri province (Thảo, 2020).
The number of species in different habitats and vegetation types were completely different. In the case of habitats, the species diversity gradually decreased from stable dune, sandy wetland, and mobile sand dune with 79 species (accounting for 98.75%), 7 species (8.75%) and 2 species (accounting for 2.5%), respectively. In the vegetation types, the number of species distributed in the shrubs is 71 species (88.75%), followed by closed forest and herbaceous vegetation with 53 species (65.0%) and 7 species (8.75%), respectively.

Table 1: List of taxa and mean of individual of tree and shrubs of Angiosperm found on natural vegetation. In which: SD: Stable dunes, SW: Sandy Wetlands, MD: Mobile dunes; CL: Closed forest, S: Shrub, HV: Herbaceous vegetation.

Taxa	Habitat	Vegetation
Annonaceae		
Meiogyne hainanensis (Merr.) Tien Ban	SD	CL,S
Polyalthia suberosa (Roxb.) Thw.	SD	S
Xylopia vielana Pierre ex Fin. & Gagn.	SD	S
Apocynaceae		
Cerbera manghas L.	SD	CL,S
Strophanthus divaricatus (Lour.) Hook. & Arn.	SD	S
Aquifoliaceae		
Ilex brevicuspis Reissek	SD	CL,S
Ilex cymosa Bl.	SD	CL,S
Clusiaceae		
Garcinia cowa Roxb.	SD	CL,S
Garcinia ferrea Pierre	SD	CL,S
Euphorbiaceae		
Alchornea rugosa (Lour.) Mull. Arg.	SD	S
Baccaurea silvestris Lour.	SD	CL
Briedelia monoica (Lour.) Merr.	SD	S

Taxa	Habitat	Vegetation
Croton heteocarpus Mull. Arg.	SD	CL,S
Fabaceae		
Archidendron bauchei (Gagnep.) I.C. Niels.	SD	CL,S
Ormosia henryi Prain	SD	S
Sindora tokinnensis K. Lars. & S.S. Lars.	SD	CL
Flacourtiaceae		
Homalium cochinchinensis (Lour.) Druce.	SD	CL,S
Sterculia lanceolata Cav.	SD	CL,S
Wikstroemia indica (L.) C. A. Mey.	SD	S
Lauraceae		
Actinodaphne pilosa (Lour.) Merr.	SD	S
Cinnamomum burmannii (Ness et. T. Nees) Blume	SD	CL,S
Cinnamomum melastomaceum Kost.	SD	CL,S
Lindera myrrha (Lour.) Merr.	SD	S
Litsea brevipes Kost.	SD	CL,S
Litsea glutinosa (Lour.) C. B. Rob.	SD	CL,S
Neolitsea merrilliana C.K. Allen	SD	CL,S
Loganiaceae		
Strychnos polyantha Pierre ex Dop	SD	CL
Melastomataceae		
Melastoma affine D. Don	SD, SW	S,HV
Osbeckia stellata Buchanan-Hamilton ex Kew Gawler	SD, SW	S,HV
Meliaceae		
Aglaia tomentosa I T.& B.	SD	S
Memecylaceae		
Memecylon umbellatum Burm. f.	SD	CL,S
Moraceae		
Ficus fulva Reinw. ex Blume	SD	CL
Ficus simplicissima Lour.	SD	CL,S
Myrsinaceae		
Ardisia crenata Sims.	SD	CL,S
Ardisia splendens Pit.	SD	S
Embelia henryi Walker.	SD	S
Embelia picta A. DC.	SD	CL,S
Rapanea linearis (Lour.) Moore.	SD	
Myrtaceae		
Baeckea frutescens L.	SD, SW	S,HV
Melaleuca cajuputi Pow.	SD, SW	CL,S,HV
Rhodamnia dumetorum (DC.) Merr.& L. M. Perry	SD	CL,S
Rhodomyrtus tomentosa (Ait.) Hassk.	SD	S
Syzygium bullockii (Hanc.) Merr. & L.M. Perry	SD	S
Syzygium corticosum (Lour.) Merr. & Perry	SD	CL,S
Syzygium lineatum (DC.) Merr.& L. M. Perry	SD	CL,S
Syzygium mekongensis (Gagn.) Merr. Perry.	SD	S
Syzygium odoratum (Lour.) DC.	SD	CL
Syzygium zeylanicum (L.) DC.	SD	CL,S
Oleaceae		
Olea dentata Wall.	SD	CL

Taxa	Habitat	Vegetation
Olea dioica Robx	SD	CL,S
Phyllanthaceae		
Antidesma bunius (L.) Spreng.	SD	S
Aporosa dioica (Robx.) Muell.-Arg	SD	CL,S
Breynia glauca Craib.	SD	S
Breynia ruticosa (L.) Hook. f.	SD	CL,S
Cleistanthus pierrei (Gagn.) Croiz.	SD	CL,S
Glochidion zeylannicum A. Juss.	SD	CL,S
Phyllanthus fasciculatus (Lour.) Mull.Arg.	SD	S
Phyllanthus thaii Thin.	SD	CL,S
Rhizophoraceae		
Carallia brachiata (Lour.) Merr.	SD	CL,S
Rosaceae		
Rhaphiolepis indica (L.) Lindl. ex Ker.	SD	CL,S
Rubiaceae		
Fagerlindia scandens (Thunb.) Tirveng.	SD	CL,S
Gardenia angusta (L.) Merr.	SD, SW	S
Ixora coccinea L.	SD	CL,S
Ixora duffii T . Moore	SD	CL,S
Pavetta cambodiensis Brem.	SD	S
Psychotria rubra (Lour.) Poir.	SD	CL,S
Psydrax umbellata (Wight) Bridson	SD	S
Rutaceae		
Acronychia pedunculata (L.)Miq.	SD	CL,S
Euodia lepta (Spreng.) Merr.	SD, SW	CL,S,HV
Severinia monophylla (L.) Tan.	SD	CL,S
Sapindaceae		
Dodonaea angustifolia L. f.	SD	S
Lepisanthes rubiginosa (Roxb.) Leenh.	SD	CL,S
Mischocarpus poilane Gagn.	SD	CL,S
Sapotaceae		
Planchonella obovata (R. Br.) Pierre	SD	S
Simaroubaceae		
Eurycoma longifolia Jack.	SD	CL,S
Tiliaceae		
Grewia laurifolia Hook. f. ex. Mast.	SD	S
Verbenaceae		
Clerodendrum robinsonii Dop	SD	CL,S
Vitex rotundifolia L.	MD	HV
Arecaceae		
Caryota mitis Lour.	SD	CL
Pandanaceae		
Pandanus tectorius Parkinson ex Zucc.	SD, SW, MD	CL,S,HV

Assemblages of species in relation to habitats and vegetation types

PERMANOVA analysis results showed statistically significant differences in community structure (species composition and density) distributed in different habitats and vegetation types (Table 2). The SIMPER test showed that the total percentage difference among habitats and vegetation types was

97.68% and 89.89%, respectively (Table 3). The species of *Melaleuca cajuputi*, *Osbeckia stellata*, *Syzygium corticosum* and *Croton heteocarpus* made up 49.4% of the major variation among habitats. The species of *Melaleuca cajuputi*, *Neolitsea merrilliana*, *Croton heteocarpus*, *Syzygium corticosum*, *Osbeckia stellata*, *Mischocarpus poilane*, *Pandanus tectorius* and *Psychotria rubra* accounted for 50.19% of the difference among the vegetation types.

This study indicated a remarkable difference in the structure of the assemblages of tree and shrub angiosperms distributed in different habitats and vegetation types. This difference closely related to species density and composition between habitats and vegetation types. In the process of forming sandy soil vegetation, the interaction between environmental factors leads to the formation of different types of habitats (Criddle *et al.*, 1994). The interaction between plants and environmental factors in different habitats has formed plant communities with different species composition (Avis and Lubke, 1996) related to the different adaptability of plants to different ecological conditions in coastal sandy soil (Hesp, 1991). According to Maun (2009), the structure and species composition of the plant communities are affected by sand mobility, wind, sand deposition, while Curreli et al (2013) recorded the diversity of plant communities also depends on water level fluctuations and inundation time.

Table 2: Result of PERMANOVA analysis among habitat and vegetation types. In which: SD: Stable dunes, SW: Sandy Wetlands, MD: Mobile dunes; CL: Closed forest, S: Shrub, HV: Herbaceous vegetation.

	p	**F**
Habitat	0.0001	12.3
SD – SW	0.0001	21.65
SD – MD	0.0002	3.215
SW – MD	0.0011	4.255
Vegetation type	0.0001	8.058
CL – S	0.0001	6.45
CL – HV	0.0001	14.14
S – HV	0.0001	8.49

Table 3: Result of SIMPER analysis. In which: SD: Stable dunes, SW: Sandy Wetlands, MD: Mobile dunes; CL: Closed forest, S: Shrub, HV: Herbaceous vegetation.

Taxon	**Contribution %**	**Cumulative %**	**Mean SD**	**Mean SW**	**Mean D**
Habitat (Overall average dissimilitary: 97.68%)					
Melaleuca cajuputi	33.87	33.87	1.53	44.5	0
Osbeckia stellate	7.076	40.95	0.097	6.19	0
Syzygium corticosum	4.507	45.45	2.63	0	0
Croton heteocarpus	4.233	49.68	2.96	0	0
Vegetation type (Overall average dissimilitary: 89.89%)					
Melaleuca cajuputi	15.88	15.88	11.2	0.0476	9
Neolitsea merrilliana	9.917	25.8	0.667	9.95	0
Croton heteocarpus	5.795	31.59	2.46	3.24	0
Syzygium corticosum	5.114	36.71	2.26	2.52	0
Osbeckia stellate	4.189	40.9	1.23	0	3
Mischocarpus poilane	3.412	44.31	1.62	1.48	0
Pandanus tectorius	3.07	47.38	0.741	0.667	1.38
Psychotria rubra	3.033	50.41	0.843	1.76	0

The Diversity indices in relation to habitats and vegetation types

The average species richness was highest in fixed sandy soils (S=10.04 and 1-D=0.78), followed by wetland sandy soils (S=2.35 and 1-D=0.35) and mobile sandy soils (S=1.00 and 1-D=0.00) (Table 3). The average richness and diversity of species were highest in closed forest (S=12.05 and 1-D=0.82), following by howling (S=8.50 and 1-D=0.70) and lowest data was recored for herbaceous vegetation (S=2.08 and 1-D=0.34) (Table 4). However, in the pools of quadrats, the species diversity was highest in shrubs and followed by forests with 71 and 52 species, respectively, while in herbaceous vegetation there were only 7 species. In addition, the diversity index of closed forest and Shrubs type was almost the same. The results of Games-Howell tests indicated the statistically significant differences in species richness and mean diversity across habitats and vegetation tests (Table 5).

During the succession process, the species assemblage has changes in species composition as well as diversity, especially in a more climax communities, species richness can be reduced due to competition between species (Pearce, 1993). Thus, the total number of species in the closed forest was lower than in the howling pattern likely due to this competition. The average richness and diversity of species in woody and bushy angiosperms were varied significantly between habitat types. Species richness and diversity were higher in permanent sandy soils than in sandy wetlands and mobile sandy dunes. The higher diversity in stable dunes were likely due to environmental disturbances. Plant diversity is influenced by changes in the environment. Ecosystems have the highest stability where they have the highest diversity (Isermann, 2011). The species richness of sandy soil plants increased with the stability of sandy soils (Abdelaal *et al.*, 2019; Ciccarelli and Bacaro, 2016; Torca *et al.*, 2019; Wang *et al.*, 2019). In mobile sand dunes, the low diversity may be due to ecological instability associated with sand burial, high salt content and poor nutrient substrates, therefore only a few specialized plant species may exist (Attorre *et al*., 2013; Nylen and Luoto, 2015). Sandy wetlands have a greater species diversity than the foredunes due to higher soil moisture levels (Lubke and Avis, 1982). However, in sandy wetlands, the habitat instability is caused by the level of water fluctuation, which controls the growth of wetland vegetation (Curreli *et al.*, 2013). Long-term waterlogging also leads to the formation of an anaerobic, oxygen-deficient environment (Cherry, 2011). Therefore, the mobility of sand and waterlogging also limit many plant species distributed in this area.

Table 4: The diversity index in relation to habitats and vegetation types. In which: SD: Stable dunes, SW: Sandy Wetlands, MD: Mobile dunes; CL: Closed forest, S: Shrub, HV: Herbaceous vegetation.

	Number of quadrats	Species richness			Simpson index		
		Pool of quadrat	Average of quadrat	Range of quadrat	Pool of quadrat	Average of quadrats	Range of quadrats
	Habitat						
SD	113	79	10.04	1 - 18	0.9594	0.78	0 - 0.93
SW	26	7	2.35	1 - 5	0.407	0.35	0 - 0.66
MD	3	2	1.00	1 - 1	0.3403	0.00	0 - 0
	Vegetation type						
CL	21	52	12.05	5 - 18	0.8995	0.82	0.57 - 0.91
S	108	71	8.50	1 - 18	0.8982	0.70	0 - 0.93
HV	13	7	2.08	1 - 5	0.6336	0.34	0 - 0.65

Table 5: The Result of Games-Howell test. In which: SD: Stable dunes, SW: Sandy Wetlands, MD: Mobile dunes; CL: Closed forest, S: Shrub, HV: Herbaceous vegetation.
*** The mean difference is significant at the 0.05 level.**

		Mean Difference	p
SD – SW	Species richness	7.70*	0.000
	Simpson index	0.43*	0.000
SD – MD	Species richness	9.04*	0.000
	Simpson index	0.78*	0.000
SW- MD	Species richness	1.35*	0.000
	Simpson index	0.35*	0.000
CL – S	Species richness	3.55*	0.000
	Simpson index	0.12*	0.001
CL - HV	Species richness	9.97*	0.000
	Simpson index	0.48*	0.000
S – HV	Species richness	6.42*	0.000
	Simpson index	0.36*	0.002

Conclusions

Angiosperm tree and shrub in the study area were quite rich in species composition. The structure of species assemblages in disparate habitat and vegetation types was completely different. The species richness and diversity were highest in closed forests and stable dunes. This study supported the hypothesis of high diversity in stable habitats and provided the scientific basis for biodiversity management and conservation in this area.

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