Indian Journal of Plant Sciences ISSN: 2319–3824
Online, International Journal, Available at http://www.cibtech.org/jps.htm
2023 Vol.12, pp.5-17/Hoang and Nguyen
Research Article (Open Access)

DIVERSITY OF TREE AND SHRUB PLANT SPECIES DISTRIBUTED ON NATURAL VEGETATION IN COASTAL SAND DUNES IN VINH LINH, QUANG TRI, VIETNAM

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ABSTRACT
The study aimed to identify the species composition and evaluate the diversity of tree and shrub plant species in the natural vegetation of the sandy coastal area in Vinh Linh district, Quang Tri province. A total of 68 random quadrats, each 10 m × 10 m in size, were conducted in the closed forest, closed shrubs, open shrubs, and herbaceous vegetation. Comparisons of species richness, Simpson diversity (1-D), and structure among vegetation types were performed using the ANOVA post-hoc Tukey test, One-way PERMANOVA, and SIMPER. UPGMA (Paired group method) was used in Cluster analysis to evaluate the close relationship in the structure of vegetation types. The study identified 47 species of trees and shrubs belonging to 41 genera and 24 families. The dominant tree species included *Gluta wrayi*, *Lithocarpus concentricus*, and *Syzygium zeylanicum*. The predominant shrub species consisted of *Croton heteocarpus*, *Lindera myrrha*, *Neolitsea merrilliana*, *Melastoma affine*, *Melaleuca cajuputi*, *Cleistanthus pierrei*, *Ixora coccinea*, *Psychotria rubra*, and *Mischocarpus poilane*. The structure of the 4 types of vegetation was clearly distinct, with an overall average dissimilarity of 76.35%. The Simpson diversity of the overall vegetation was 0.93, with a mean of 0.77, ranging from 0-0.9. The average species richness of overall vegetation was 9.1 species, ranging from 1-15 species. The research results provide essential scientific information for the conservation and restoration of vegetation in the coastal sandy area of Quang Tri province.

Keywords: *Coastal sand dune, diversity, shrub, tree, Vietnam*

INTRODUCTION
Coastal sands are the junctions between the ocean and the land (Martins *et al*., 2013). Coastal sand dunes are formed along the coast, at the high tide level (Maun, 2009). Coastal sandy soil vegetation is the result of interactions among factors such as wind, sand accretion, atmospheric salt, and plant adaptations (Maun, 2009; Carter *et al*., 1990). Plants on sandy soils play an important role in protecting the inland from natural disasters such as storms, wind, and sea level rise. Besides, they participate in water purification, groundwater replenishment, and sand movement prevention. Plants on sandy soils also provide habitats for many animal species and protect biodiversity (Comor *et al*., 2008; Williams *et al*., 1997; Curr *et al*., 2000; Poyyamoli *et al*., 2012).
The coastal sandy soil ecosystem is quite diverse (Louisse and Van der Meulen, 1991), and the interaction of environmental factors with vegetation has created habitats with different species compositions and diversity of species (Avis and Lubke, 1996). However, the sandy soil ecosystem is a sensitive ecosystem that is easily destroyed by various human activities (Curr *et al*., 2000) such as the construction of roads, and houses, production of forest planting activities, and aquaculture. These activities have disrupted vegetation growth, reduced vegetation cover, fragmented habitats, and reduced biodiversity (Laurance and Useche, 2009).
Though the natural vegetation in the coastal sandy area of Vinh Linh district is just a small area, it was greatly affected by war and human activities (Tu *et al*., 2004). Natural vegetation has decreased due to afforestation activities to meet the demand of wood raw-material, road construction, housing construction, aquaculture, etc. (Tu, 2007). The strong exploitation of sand and minerals (titanium) in the coastal area is also the cause of the decline in vegetation in Vinh Linh (Duc, 2015). The sandy soil of Quang Tri province is assessed to be at risk of erosion (Ky *et al*., 2006-2007), with the wind being the main cause (Viet *et al*., 2014). The reduction in

vegetation area makes the sand exposed, under the influence of the wind, the soil is eroded, and the sand is carried further inland by the wind, affecting production activities and human life. Therefore, restoration and conservation of vegetation are very necessary. This research provides scientific information on native plant species for vegetation restoration and conservation.

MATERIALS AND METHODS

Study site

Vinh Linh district is located in the north of Quang Tri province, in central Vietnam. The sandy land is located in the east of Vinh Linh district, adjacent to the East Sea, with a coastline of 25 km long. The sandy area of Vinh Linh district has a latitude from 17° 9'47.29"N to 17° 5'35.53"N, and a longitude from 107° 0'41.26"E to 107° 5'4.60" E. It expands 4 to 5 km inland, creating many different types of habitats and vegetation. The sandy

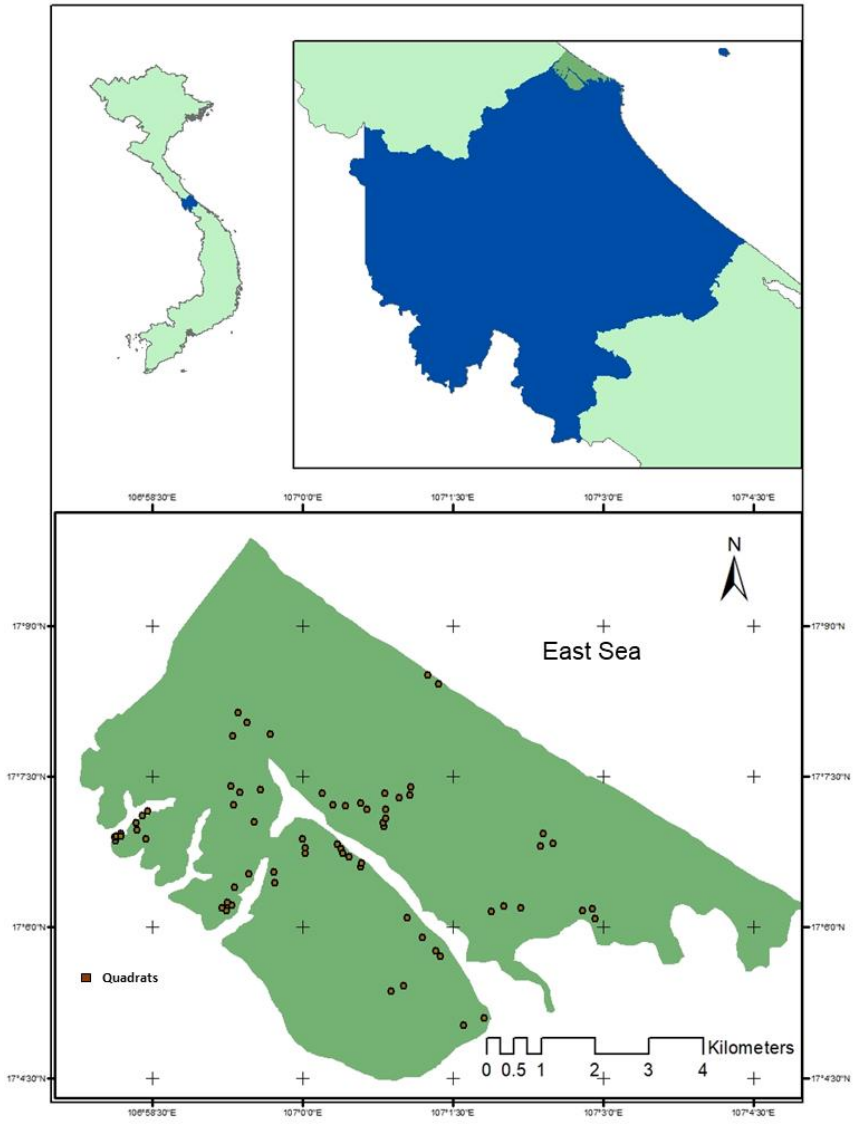

Figure 1: Coastal sand dune area of Vinh Linh district

soil of Vinh Linh district includes sand dunes 20 - 30 m high, and in some places, the dunes can reach up to 70 m high, in low-lying terrain on sandy soil with wetlands (Tu, 2007). The climate of sandy soil of Vinh Linh

district is characterized by a tropical monsoon climate. The rainy season starts from August to December, the dry season takes place from January to July (Loi, 2015), and the total rainfall is less than 2,200 mm (Tuan *et al*., 2014). Rainfall is mainly concentrated in the rainy season months, ranging from 34.6 mm - 747.5 mm, while in the dry season, the average rainfall ranges from 30.8 mm - 193.8 mm (Quang Tri Statistical Office, 2021). The average temperature in the year is 25.8°C, with a high temperature ranging from 29.3-30.6°C in the dry season and lower from 21.3-28.2°C in the rainy season (Quang Tri Statistical Office, 2021). Temperatures between the two seasons sometimes differ by 10 - 20°C (Hien *et al*., 2019).

Data collection

Data were collected from natural vegetation distributed in mobile sandy soils and fixed sandy soils. Natural vegetation includes closed forests and closed shrubs (with tree and shrub coverage greater than 60%), opened shrubs (with shrub coverage less than 60%), and herbaceous vegetation. A total of 68 random quadrats of size 10m × 10m were conducted (de Pádua Teixeira *et al*., 2011). Species composition and the number of individuals of shrubs and trees taller than 0.5 m were collected. The investigation took place from April 2018 to June 2020.

Data analysis

One-way PERMANOVA was used to test the hypothesis of differences in species composition and abundance among vegetation types (Anderson, 2001). SIMPER was used to determine the degree of difference in species composition, abundance among vegetation types, and the contribution of each species to that difference (Clarke and Warwick, 1994). Both One-way PERMANOVA and SIMPER use abundance data with the Bray-Curtis similarity index. Cluster analysis by paired group method (UPGMA) using abundance data by Bray-Curtis similarity index to evaluate the close relationship in the structure of vegetation types. Cluster analysis by UPGMA using data on the presence/absence of species according to the Jaccard similarity index to determine the close relationship in species composition of vegetation in coastal sandy areas of Vinh Linh district, Gio Linh district, Trieu Phong-Hai Lang district belongs to Quang Tri province. Species richness and Simpson diversity (1-D) were also used to evaluate diversity among vegetation types. ANOVA post-hoc Tukey test was used to compare mean values of species richness and Simpson diversity (1-D) among vegetation types. Data were analyzed using PAST version 4 (Hammer *et al*., 2001).

Nomenclature: Following an Illustrated Flora of Vietnam, vol. 1 to 3 (Ho PH, 1999-2003) and Flora of Vietnam vol. 1 to 11 (Vietnam Academy of Science and Technology, 2002-2007).

RESULTS AND DISCUSSION

Species composition

The survey results identified 47 species belonging to 41 genera and 24 families, distributed in mobile dunes and stable dunes (Table 1), while wetlands were devoid of trees and shrubs. Myrtaceae had the largest number of species, with 7 species, followed by Rubiaceae and Phyllanthaceae, each with 5 species, and Lauraceae with 3 species. Euphorbiaceae, Rutaceae, Fabaceae, Melastomataceae, Thymelaeaceae, Myrsinaceae, and Fagaceae each had 2 species, while the remaining plant families each had only 1 species. The genus *Syzygium* had the largest number of species, with 4 species, followed by *Psychotria*, *Phyllanthus*, and *Wikstroemia*, each with 2 species, and the remaining genera had 1 species each. In the total of 47 species, there were 28 species of trees and 19 species of shrubs.

Myrtaceae, Rubiaceae, Phyllanthaceae, Lauraceae, and the genus *Syzygium* were also recorded as the family and genus with the dominant number of tree and shrub species in sandy soils in Gio Linh district, Hai Lang - Trieu Phong district, Quang Tri province (Thao, 2020; Thao, 2022). This result showed that these plant families and genera had a dominant number of species in the coastal sandy soils of Quang Tri province.

Table 1: List of taxa, habits, and vegetation types of tree and shrubs of Angiosperm distributed on natural vegetation. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

Taxa	Habits	Vegetation
Anacardiaceae		
Gluta wrayi King.	Tree	CF, CS, OS
Aquifoliaceae		
Ilex brevicuspis Reissek	Tree	CS
Clusiaceae		
Garcinia ferrea Pierre	Tree	CS
Euphorbiaceae		
Alchornea rugosa (Lour.) Mull. Arg.	Tree	CS
Croton heteocarpus Mull. Arg.	Shrub	CF, CS, OS
Fabaceae		
Ormosia henryi Prain	Tree	CF, CS, OS
Archidendron bauchei (Gagnep.) I.C. Niels.	Tree	CF, CS, OS
Fagaceae		
Castanopsis indica (Rox. ex Lindl) A. DC.	Tree	CS
Lithocarpus concentricus (Lour.) Hjelmq.	Tree	CF, CS
Flacourtiaceae		
Scolopia spinosa (Roxb.) Warb.	Tree	OS
Lauraceae		
Cinnamomum burmannii (Ness et. T. Nees) Blume	Shrub	CF, CS
Lindera myrrha (Lour.) Merr.	Tree	CF, CS, OS
Neolitsea merrilliana C.K. Allen	Shrub	CF, CS
Melastomataceae		
Melastoma affine D. Don	Shrub	CF, CS, OS
Osbeckia stellata Buchanan-Hamilton ex Kew Gawler	Shrub	CS
Memecylaceae		
Memecylon umbellatum Burm. F.	Shrub	CS
Myrsinaceae		
Rapanea linearis (Lour.) Moore.	Tree	CS, OS
Embelia picta A. DC.	Tree	CS
Myrtaceae		
Melaleuca cajuputi Pow.	Tree	CS
Rhodomyrtus tomentosa (Ait.) Hassk.	Shrub	CS, OS
Rhodamnia dumetorum (DC.) Merr.& L. M. Perry	Tree	CF, CS, OS
Syzygium odoratum (Lour.) DC.	Shrub	CS
Syzygium zeylanicum (L.) DC.	Tree	CF, CS, OS
Syzygium mekongensis (Gagn.) Merr. Perry.	Tree	CS, OS
Syzygium bullockii (Hanc.) Merr. & L.M. Perry	Shrub	CF, CS, OS
Oleaceae		
Olea dioica Robx	Tree	CS, OS
Pandanaceae		
Pandanus tectorius Parkinson ex Zucc.	Shrub	CS
Phyllanthaceae		
Breynia ruticosa (L.) Hook. F.	Shrub	CS, OS
Cleistanthus pierrei (Gagn.) Croiz.	Tree	CF, CS
Phyllanthus thaii Thin.	Shrub	CS

Taxa	Habits	Vegetation
Phyllanthus reticulatus Poir.	Shrub	CS
Aporosa dioica (Robx.) Muell.-Arg	Tree	CS
Rhizophoraceae		
Carallia brachiata (Lour.) Merr.	Tree	CS
Rosaceae		
Rhaphiolepis indica (L.) Lindl. ex Ker.	Tree	CF, CS, OS
Rubiaceae		
Fagerlindia scandens (Thunb.) Tirveng.	Tree	CF, CS
Ixora coccinea L.	Shrub	CF, CS, OS
Psychotria rubra (Lour.) Poir.	Shrub	CF, CS, OS
Psychotria montana Blume	Tree	CF, CS
Randia pinosa (Thunb.) Poir.	Shrub	CS
Rutaceae		
Euodia lepta (Spreng.) Merr.	Tree	CS, OS
Severinia monophylla (L.) Tan.	Shrub	CS, OS
Sapindaceae		
Mischocarpus poilane Gagn.	Tree	CF, CS, OS
Simaroubaceae		
Eurycoma longifolia Jack.	Tree	CF, CS
Theaceae		
Camellia sinensis (L.) Kuntze	Tree	CS
Thymelaeaceae		
Wikstroemia indica (L.) C. A. Mey.	Shrub	CF, CS
Wikstroemia meyeniana Warb.	Shrub	CF
Verbenaceae		
Vitex rotundiflora L.	Shrub	HV

The dominant tree plant species in the coastal sandy soil of Vinh Linh district included *Gluta wrayi, Lithocarpus concentricus,* and *Syzygium zeylanicum*. The predominant shrub species consisted of *Croton heteocarpus*, *Lindera myrrha*, *Neolitsea merrilliana*, *Melastoma affine*, *Melaleuca cajuputi*, *Cleistanthus pierrei*, *Ixora coccinea*, *Psychotria rubra*, and *Mischocarpus poilane*. In the sandy coastal areas of Gio Linh, Hai Lang-Trieu Phong, *Alchornea rugosa*, *Croton heteocarpus, Lindera myrrha, Neolitsea merrilliana, Osbeckia stellata, Rapanea linearis, Melaleuca cajuputi, Syzygium zeylanicum, Baeckea frutescens, Syzygium corticosum, Cleistanthus pierrei, Phyllanthus thaii, Ixora coccinea, Mischocarpus poilane,* and *Pandanus tectorius* were dominant species (Thao, 2020; Thao, 2022). These dominant species reflect their good adaptability to the sandy coastal areas of Quang Tri province. These species suggest the selection of native plant species to plant and restore vegetation in the sandy coastal areas of Quang Tri province.

The total number of tree and shrub plant species in the coastal sandy soil of Vinh Linh district, including 47 species, was lower than the total number of species in the coastal sandy area of Gio Linh district and the sandy soil of Trieu Phong-Hai Lang district with 55 and 80 species, respectively (Table 2). This result reflects that the number of tree and shrub plant species in the coastal sandy area of Quang Tri province increases gradually from north to south, or the number of species increases in the direction from high latitude to low latitude. In Quang Tri province, the average annual temperature tends to increase gradually from north to south (Tuan *et al*., 2014). The sandy area of Vinh Linh district is located in the north of Quang Tri province, including sand dunes with a height of 20 - 30 m, and a lower elevation of sand dunes in the south (under 20 m) (Tu, 2007).

The difference in climatic and topographical conditions contributes to the difference in the number of species of these 3 sandy lands. The wetland sandy soil in Vinh Linh did not have the presence of trees and shrubs, which is different from Gio Linh, and Trieu Phong - Hai sandy soils. The different types of communities and

Table 2: Comparison of plant species composition of coastal sandy areas in Vinh Linh, Gio Linh, and Trieu Phong - Hai Lang districts. In which: SD: Stable dune, W: Wetland, MD: Mobile dune, CSD: Coastal sand dune.

Taxa	Habitats			Density		
	CSD Vinh Linh	CSD Gio Linh	CSD Trieu Phong – Hai Lang	CSD Vinh Linh	CSD Gio Linh	CSD Trieu Phong – Hai Lang
Anacardiaceae						
Gluta wrayi King.	SD	-	-	2.03	0	0
Annonaceae						
Meiogyne hainanensis	-	SD	SD	0	0.15	0.32
Polyalthia suberosa	-	-	SD	0	0	0.04
Xylopia vielana	-	-	SD	0	0	0.06
Apocynaceae						
Cerbera manghas	-	-	SD	0	0	0.06
Strophanthus divaricatus	-	-	SD	0	0	0.01
Aquifoliaceae						
Ilex brevicuspis	SD	-	SD	0.07	0	0.09
Ilex cymosa	-	-	SD	0	0	0.04
Clusiaceae						
Garcinia ferrea	SD	SD	SD	0.03	0.06	0.21
Garcinia cowa			SD	0	0	0.06
Euphorbiaceae						
Alchornea rugosa	SD	SD	SD	0.01	1.13	1.21
Croton heteocarpus	SD	SD	SD	2.79	0.23	2.35
Briedelia monoica	-	SD	SD	0	0.11	0.07
Baccaurea silvestris	-	-	SD	0	0	0.01
Fabaceae						
Ormosia henryi	SD	SD	SD	0.74	0.02	0.13
Archidendron bauchei	SD	SD	SD	0.84	0.7	0.19
Sindora tokinnensis	-	-	SD	0	0	0.01
Fagaceae						
Castanopsis indica	SD	-	-	0.44	0	0
Lithocarpus concentricus	SD	SD	-	3.51	0.06	0
Flacourtiaceae						
Scolopia spinosa	SD	SD	-	0.04	0.02	0
Homalium cochinchinensis	-	SD	SD	0	0.02	0.06
Lauraceae						
Cinnamomum burmannii	SD	SD	SD	0.38	0.21	0.28
Lindera myrrha	SD	SD	SD	1.16	0.36	0.14
Neolitsea merrilliana	SD	SD	SD	1.97	0.26	1.98
Litsea glutinosa	-	SD	SD	0	0.02	0.34
Actinodaphne pilosa	-	SD	SD	0	0.04	0.02
Cinnamomum melastomaceum	-	SD	SD	0	0.47	0.32

Taxa	Habitats			Density		
	CSD Vinh Linh	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**	**CSD Vinh Linh**	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**
Litsea brevipes	-	-	SD	0	0	0.04
Loganiaceae						
Strychnos polyantha	-	-	SD	0	0	0.01
Melastomataceae						
Melastoma affine	SD	SD, W	SD, W	1.22	6.02	0.61
Osbeckia stellata	SD	SD, W	SD, W	0.35	4.83	1.21
Memecylaceae						
Memecylon umbellatum	SD	SD, W	SD, W	0.07	0.38	0.54
Meliaceae						
Aglaia tomentosa	-	-	SD	0.69	0.06	0.19
Moraceae						
Ficus fulva	-	-	SD	0	0	0.01
Ficus simplicissima	-	-	SD	0	0	0.04
Myrsinaceae						
Rapanea linearis	SD	SD, W	SD	0.21	0.87	1.04
Embelia picta	SD	SD	SD	0.01	0.19	0.44
Ardisia splendens	-	SD	SD	0	0.13	0.07
Embelia henryi	-	SD	SD	0	0.02	0.01
Ardisia crenata	-	-	SD	0	0	0.27
Myrtaceae						
Melaleuca cajuputi	SD	SD, W	SD, W	2.28	5.83	9.36
Rhodomyrtus tomentosa	SD	SD	SD	0.69	0.06	0.19
Rhodamnia dumetorum	SD	SD	SD	0.6	0.11	0.32
Syzygium odoratum	SD	-	SD	0.06	0	0.01
Syzygium zeylanicum	SD	SD, W	SD	7.71	1.4	0.57
Syzygium mekongensis	SD	SD	SD	0.72	0.09	0.15
Syzygium bullockii	SD	SD, W	SD	0.13	0.26	0.14
Baeckea frutescens	-	Wet land	SD, W	0	0.06	1.85
Syzygium corticosum	-	-	SD	0	0	2.1
Syzygium lineatum	-	-	SD	0	0	0.05
Oleaceae						
Olea dioica	SD	SD	SD	0.4	0.79	0.21
Olea dentata	-	-	SD	0	0	0.01
Phyllanthaceae						
Breynia ruticosa	SD	SD, W	SD	0.24	0.53	0.23
Cleistanthus pierrei	SD	SD	SD	4.91	1.06	0.96
Phyllanthus thaii	SD	SD	SD	0.13	1.79	1.04
Phyllanthus reticulatus	SD	-	-	0.38	0	0
Aporosa dioica	SD	SD	-	0.04	0.55	0.13
Antidesma bunius	-	SD	SD	0	0.02	0.02
Phyllanthus fasciculatus	-	SD	SD	0	0.15	0.08

Taxa	Habitats			Density		
	CSD Vinh Linh	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**	**CSD Vinh Linh**	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**
Glochidion zeylannicum	-	-	SD	0	0	0.09
Breynia glauca	-	-	SD	0	0	0.01
Antidesma bunius	-	-	SD	0	0.02	0.02
Rhizophoraceae						
Carallia brachiata	SD	SD	SD	0.06	0.11	0.18
Rosaceae						
Rhaphiolepis indica	SD	-	SD	0.18	0	0.13
Rubiaceae						
Fagerlindia scandens	SD	SD	SD	0.65	0.34	0.25
Ixora coccinea	SD	SD	SD	3.62	1	0.6
Psychotria rubra	SD	SD	SD	1.99	0.66	0.9
Psychotria montana	SD	-	-	0.68	0	0
Randia pinosa	SD	-	-	0.07	0	0
Gardenia angusta	-	SD, W	SD, W	0	0.57	0.13
Pavetta cambodiensis	-	SD	SD	0	0.04	0.01
Ixora duffii	-	-	SD	0	0	0.03
Psydrax umbellata	-	-	SD	0	0	0.24
Rutaceae						
Euodia lepta	SD	SD, W	SD, W	0.01	0.98	0.28
Severinia monophylla	SD	SD	SD	0.09	0.4	0.35
Acronychia pedunculata	-	SD, W	SD	0	0.38	0.79
Glycosmis pentaphylla	-	SD	-	0	0.02	0
Sapotaceae						
Planchonella obovata	-	SD	SD	0	0.15	0.2
Sapindaceae						
Mischocarpus poilane	SD	SD	SD	2.44	0.66	1.47
Dodonaea angustifolia	-	-	SD	0	0	0.04
Lepisanthes rubiginosa	-	-	SD	0	0	0.13
Simaroubaceae						
Eurycoma longifolia	SD	SD	SD	0.22	0.45	0.39
Sterculiaceae						
Sterculia lanceolata	-	-	SD	0	0	0.04
Theaceae						
Camellia sinensis	SD	-	-	0.01	0	0
Thymelaeaceae						
Wikstroemia indica	SD	SD	SD	0.12	0.34	0.41
Wikstroemia meyeniana	SD	-	-	0.01	0	0
Tiliaceae						
Grewia laurifolia	-	-	SD	0	0	0.01
Verbenaceae						
Vitex rotundiflora	MD	MD	MD	0.09	0.06	0.03

Taxa	Habitats			Density		
	CSD Vinh Linh	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**	**CSD Vinh Linh**	**CSD Gio Linh**	**CSD Trieu Phong – Hai Lang**
Clerodendrum paniculatum	-	SD	-	0	0.02	0
Clerodendrum robinsonii	-	-	SD	0	0	0.03
Arecaceae						
Caryota mitis	-	-	SD	0	0	0.01
Pandanaceae						
Pandanus tectorius	SD	SD, W, MD	SD, W, MD	0.13	1.28	0.79
Poaceae						
Bambusa bambos	-	W	-	0	0.13	0
Total species	**47**	**55**	**80**			

their distributions are related to dune morphology, soil, and climate differences (Moreno-Casasola and Espejel, 1986). The topography of the sandy area contributes to different microclimates that contribute to the diversity of plants (Sewerniak and Puchałka, 2020). The results of cluster analysis (UPGMA method) by Jaccard similarity index showed that the species composition in the sandy soils of Vinh Linh and Gio Linh had a closer relationship than Trieu Phong - Hai Lang district (Cophenetic correlation = 0.531) (Figure 2).

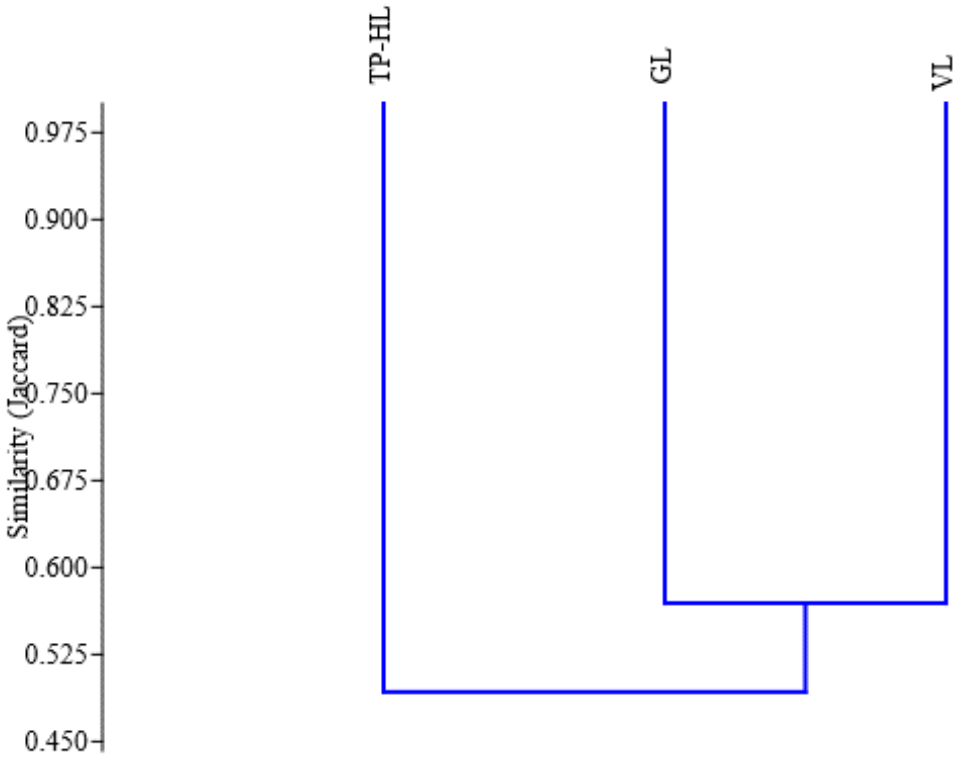

Figure 2: Dendrogram based on the paired group (UPGMA) using similarity Jaccard index for clustering of three sandy coastal areas of Quang Tri province. In which: GL: Gio Linh district, VL: Vinh Linh district, TP-HL: Trieu Phong-Hai Lang district

Assemblages of species

The results of One-way PERMANOVA showed that the structure of species composition and abundance of species in 4 vegetation types were statistically significant (p(PERMANOVA) = 0.0001, F = 5.193) (Table 3). The results of cluster analysis (UPGMA method) by the Brey-Curtis similarity index showed that closed shrubs and closed forests had a close relationship, opened shrubs had a closer relationship with the group of closed forest and closed shrubs than grasslands (Cophenetic correlation = 0.998) (Figure 3). The results of SIMPER analysis showed that the overall average dissimilarity among the vegetation was 76.35%, with 6 species making up 49.5% of the total difference: *Syzygium zeylanicum*, *Melaleuca cajuputi*, *Cleistanthus pierrei*, *Lithocarpus concentricus*, *Mischocarpus poilane*, and *Ixora coccinea* (Table 4).

Table 3: Result of One – way PERMANOVA. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

	p	F
PERMANOVA	0.0001	5.193
Pairwise		
CF - CS	0.0015	2.945
CF - OS	0.0002	5.967
CF - HV	0.0155	9.218
CS - OS	0.0001	5.458
CS - HV	0.0012	6.613
OS - HV	0.0279	5.099

In the total of 47 species, *Vitex rotundiflora* was only distributed in herbaceous vegetation on mobile sandy soils, *Wikstroemia meyeniana* was only distributed in closed forests, *Castanopsis indica* was only distributed in opened shrubs, and 17 species (*Castanopsis indica*, *Camellia sinensis*, *Garcinia ferrea*, *Embelia picta*, *Phyllanthus thaii*, *Phyllanthus reticulatus*, *Aporosa dioica*, *Alchornea rugosa*, *Briedelia monoica*, *Memecylon umbellatum*, *Osbeckia stellata*, *Melaleuca cajuputi*, *Syzygium odoratum*, *Carallia brachiata*, *Ilex brevicuspis*, *Randia pinosa*, *Pandanus tectorius*) were only distributed in closed shrubs.

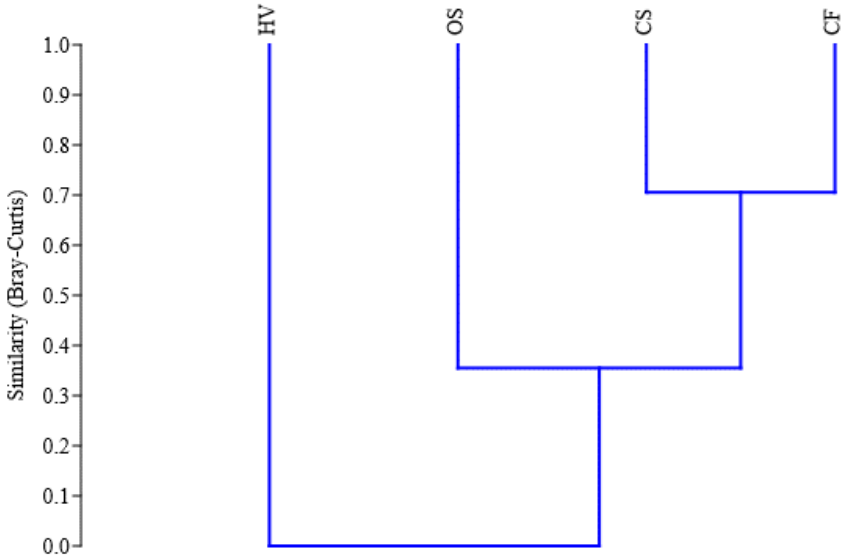

Figure 3: Dendrogram based on the paired group (UPGMA) using similarity Bray-Curtis index for clustering of four vegetation types. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

Table 4: Result of SIMPER. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

Taxon	Contribution %	Cumulative %	Mean HV	Mean CF	Mean CS	Mean OS
Syzygium zeylanicum	11.76	11.76	0	4.6	8.27	10.4
Melaleuca cajuputi	9.982	21.74	0	0	0	22.1
Cleistanthus pierrei	8.776	30.51	0	3.2	6.16	0
Lithocarpus concentricus	7.017	37.53	0	4.1	4.04	0
Mischocarpus poilane	6.162	43.69	0	4.7	1.94	3.43
Ixora coccinea	5.811	49.5	0	3.3	3.94	2.86
Overall average dissimilarity = 76.35%						

The Diversity indices

Species richness and Simpson diversity in 4 vegetation types are presented in Table 5. The species richness of the coastal sand dunes of Vinh Linh district was 47 species of trees and shrubs, and Simpson diversity was 0.93. The average species richness per quadrat of overall vegetation was 9.1 species, ranging from 1 to 15 species. The average richness of species per quadrat was highest in the closed shrubs with 9.6 species, followed by the opened shrubs (9 species) and closed forest (8.1 species), and the lowest was the herbaceous vegetation with only 1 species. The average Simpson diversity per quadrat of overall vegetation was 0.77, ranging from 0-0.90. The average diversity of each quadrat was highest in the closed forest (0.82), followed by closed shrubs (0.80), opened shrubs (0.68), and lowest in herbaceous vegetation (0.00).

The species richness of herbaceous vegetation was a statistically significant difference among closed forests, closed shrubs, and opened shrubs. Vegetation types such as closed forests, closed shrubs, and opened shrubs, the species richness were not statistically significant. Simpson's diversity of herbaceous vegetation had a statistically significant difference with closed forests, closed shrubs, and opened shrubs. Diversity also had statistically significant difference among closed forests, closed shrubs, and opened shrubs (Table 6).

During ecological succession, when communities reach their peak, species richness can decrease due to competition between species (Pearce, 1993). Therefore, the average species richness in the closed forest (8.1 species) was lower than that of closed shrubs (9.6 species) and opened shrubs (9.0 species), possibly due to competition between species. Besides, the average diversity in the closed forest was the highest (0.82), which was also consistent with the argument of Martinez and Psuty (2007) when the process of succession takes place, the species diversity increases.

Table 5: The diversity index in relation to vegetation types. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

		Species richness			**Simpson index**		
Vegetations	Number of quadrats	Pool of quadrat	Average of quadrat	Range of quadrat	Pool of quadrat	Average of quadrat	Range of quadrat
CF	10	23	8.1	5-11	0.91	0.82	0.75-0.87
CS	49	42	9.6	2-15	0.91	0.80	0.5-0.90
OS	7	22	9	6-12	0.84	0.68	0.47-0.83
HV	2	1	1	1-1	0	0	0-0
Overall Vegetations	**68**	**47**	**9.1**	**1-15**	**0.93**	**0.77**	**0-0.9**

Table 6: Result of ANOVA, post hoc test Tukey. In which: CF: Closed forest, CS: Closed Shrub, OS: Opened Shrub, HV: Herbaceous vegetation.

Vegetations	Diversity indices	Mean Difference	p
CS - CF	Species richness	1.55	0.326
	Simpson index	0.02	0.886
CF - OS	Species richness	0.90	0.897
	Simpson index	0.15*	0.006
CF - HV	Species richness	7.10*	0.005
	Simpson index	0.82*	0.000
CS - OS	Species richness	0.65	0.926
	Simpson index	0.13*	0.004
CS - HV	Species richness	8.65*	0.000
	Simpson index	0.80*	0.000
OS - HV	Species richness	8.00*	0.002
	Simpson index	0.68*	0.000

CONCLUSION

The study determined the composition of tree and shrub plant species in the coastal sand dunes of Vinh Linh district, Quang Tri province as well as identified the dominant species distributed in the study site.

The structure of the 4 types of vegetation was varied. The diversity of tree and shrub species in the study site was quite high. The study provided scientific information for the conservation and restoration of coastal vegetation in Quang Tri province.

ACKNOWLEDGEMENT

Sincere thanks are due to the University of Education, Hue University for supporting the demonstration plant laboratory, and would like to express deep gratitude to the local committee for supporting the sampling.

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Indian Journal of Plant Sciences ISSN: 2319–3824
Online, International Journal, Available at http://www.cibtech.org/jps.htm
2023 Vol.12, pp.5-17/Hoang and Nguyen
Research Article (Open Access)

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