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DIVERSITY OF TREES AND SHRUBS DISTRIBUTED ON NATURAL VEGETATION IN INLAND SANDY AREA OF HAI LANG, QUANG TRI, VIETNAM

Hoang Xuan Thao*
University of Education, Hue University, Hue City, 49000, Vietnam
***** *Author for Corresponding: hoangxuanthao@dhsphue.edu.vn*

ABSTRACT
The study aimed to identify the species composition and diversity of trees and shrubs in the Hai Lang inland sandy area, Quang Tri province. A total of 123 quadrats, each measuring 10 m × 10 m, were randomly conducted in natural vegetation which was distributed in three habitat types: wetlands, humid stable dunes, and arid stable dunes. The assemblages of species, species richness, and Simpson diversity (1-D) of the habitat types were compared using One-way PERMANOVA, SIMPER, and One-way ANOVA post-hoc Tukey test. UPGMA was used to evaluate the close relationship between the assemblages of species among habitat types and species composition among the study site and coastal sandy areas of Quang Tri province. A total of 91 species belonging to 69 genera and 39 families were identified. The natural vegetation cover in the Hai Lang inland sandy area was composed of 11 plant biogeographic elements. The major elements were Indochinese (20 species, 21.98%), followed by Endemic (17 species, 18.68%), Tropical Asian (16 species, 17.58%), and Indian (12 species, 13.19%). The assemblages of species in different habitats were statistically significant, with a total difference of up to 94.44%, with eight species contributing to 48.67% of the total difference. The species richness across the entire vegetation cover was 91 species, with an average of 9.11 and ranging from 1 to 20 species. The Simpson diversity across the entire vegetation was 0.9560, with an average of 0.7557 and ranging from 0 to 0.9256. Species richness and diversity among plant communities in different habitats were statistically significant. The study provides necessary scientific information for the conservation and restoration of vegetation on sandy soils in Quang Tri.

Keywords: *Diversity, Inland Sandy Area, Shrub, Tree, Vietnam*

INTRODUCTION
The formation of vegetation in sandy areas is related to environmental factors such as erosion, sedimentation, sand movement, wind, currents, precipitation, and plant cover (Chadwick and Dalke, 1965; El-Sheikh *et al*., 2021). The interaction between plants and environmental factors creates different habitats with communities with different species composition and diversity (Avis and Lubke, 1996). The sandy area is a sensitive ecosystem that can be easily destroyed by human activities (Curr *et al*., 2000) including the construction of residential areas, roads, agricultural cultivation, and planting of forests for economic purposes. These activities change the distribution of water and nutrients in the environment (El-Sheikh *et al*., 2021; El-Sheikh *et al*., 2010; Acosta *et al*., 2005). In addition, human impact disrupts vegetation growth, reduces vegetation coverage, causes sand movement, fragment habitats, and decreases biological diversity (Laurance and Useche, 2009).
Located in North Central Vietnam, Quang Tri province is characterized by a coastal plain area with sandbars adjacent to the sea and deep inland sandy areas (Tu, 2007). The formation of the sandy area in Quang Tri, as well as in Central Vietnam, is due to the movement of the Earth's crust and marine activities during the Middle Pleistocene (700,000 years ago), the sea receded at the end of the late Holocene (4,000 years ago), combined with the tropical monsoon climate that accelerated erosion processes, creating the current sandy strips along the Central Vietnam coast (Ky, 2004; Lieu, 1978; Hoang and Thao, 2015). After the sea

receded, plants dispersed, established, and adapted to the natural conditions of the sandy area, thus leading to the formation of vegetation (Tu, 2007). Sandy area is a harsh environment, characterized by low nutrient levels and limited access to water (Maun, 2009). Therefore, vegetation plays an important role in filtering water and supplementing groundwater sources, preventing sand mobility, and increasing organic matter in the sand. Vegetation distribution in sandy areas also provides habitats for many animal species, effectively protecting biodiversity (Comor *et al*., 2008; Williams *et al*., 1997; Curr *et al*., 2000).

The inland sandy area of Hai Lang, a district in Quang Tri province, is an extensive inland sandy area that is separated from the coastal sand dunes. This area comprises various habitats, including arid stable dunes, humid stable dunes, and wetlands (Tu, 2007). The diversity of habitats contributes to the diversity of plants distributed here. Places with favorable water supply conditions are exploited by local people for agriculture, animal husbandry, afforestation, residential areas, and tourism, leading to a decrease in the natural vegetation area. The sandy areas in Quang Tri are highly susceptible to erosion, with wind being the primary erosion factor (Ky *et al*., 2006-2007). Therefore, the presence of vegetation plays an important role in maintaining biodiversity, supporting local livelihoods, and preserving the culture of local people. Some tree and shrub vegetation are considered “forbidden forests” or “sacred forests” by local communities and are protected. Despite some studies focusing on sandy area vegetation in Central Vietnam, the sandy area in Hai Lang district, Quang Tri province, has not received much attention. By identifying the species composition and the diversity of tree and shrub plants in the natural vegetation of this area, the study aims to provide scientific information to support vegetation conservation efforts in the sandy areas of Quang Tri province.

MATERIALS AND METHODS

Study site

The sandy area of Hai Lang district is located in the southern part of Quang Tri province (Latitude 16°38’16.03"N to 16°45’17.47"N, Longitude 106°40’32.40"E to 106°43’44.73"E) (Figure 1). It is an inland sandy area, located approximately 7.4 km from the coast and extending 15.7 km inland. This area is 15 km long and 7.7 km wide and has an area of 43.5 square kilometers. The terrain is relatively flat and forms many different landscapes such as arid stable dunes, humid stable dunes, and wetlands (Tu *et al*., 2004). Arid stable dunes represent dry sand dunes not inundated with water. Humid stable dunes are sand dunes nearer to water sources such as swamps and lakes, making the sand moister. Wetlands are periodically or frequently flooded sandy areas. The vegetation in this area is diverse, consisting of grasslands, shrubs, and forests. The study site experiences a tropical monsoon climate with two primary seasons: the dry season from January to July and the rainy season from August to December (Loi, 2015). The average annual temperature in most areas of the district ranges from 24 to 25°C. The highest temperatures, occurring from May to July, reach around 35°C, sometimes approaching 40°C. The lowest temperature, recorded from January to February, is around 18°C, sometimes dropping to 12-13°C. The average annual rainfall is from 2,500 - 2,700 mm, with the total rainfall mainly concentrated in September to November, accounting for 75 - 80% of the total annual rainfall. The distribution of rainy days is uneven, with an average of 17 - 18 rainy days per month during the peak months. The hot and dry southwest wind blows from April to August every year. The hot and dry southwest wind has significantly increased the severity of drought periods, increased evaporation, reduced air humidity, depleted surface water sources, and lowered groundwater levels (Hai Lang District People’s Committee, 2021).

Data collection

A total of 123 random quadrats measuring 10 m x 10 m (Lubke *et al*., 1996) were conducted in natural vegetation with tree and shrub plants. These quadrats were distributed across three habitat types: arid stable dunes, humid stable dunes, and wetlands. The species composition and number of tree and shrub plant individuals taller than 0.5m were collected. The study was conducted from April 2018 to June 2020. The geographical elements of each species were determined according to Chan *et al*. (1999).

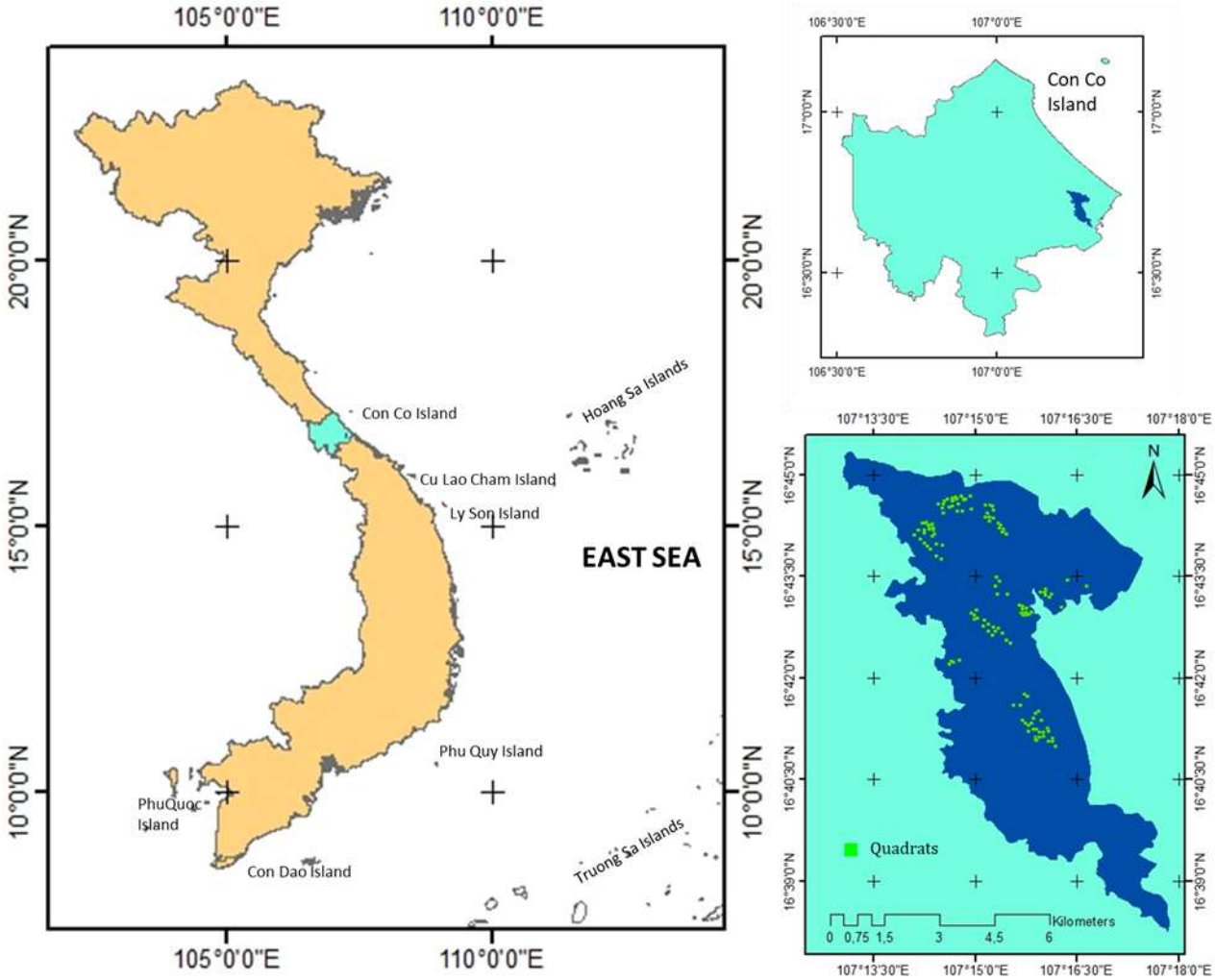

Figure 1: Inland sandy area of Hai Lang district

Data analysis

To test the hypothesis of community structure differences (species composition and richness) among habitats, one-way PERMANOVA was used (Anderson, 2001). SIMPER analysis was used to evaluate the degree of differences in species composition and richness among habitats, as well as the contribution of each species to the total difference among habitats (Clarke *et al*., 2014). Species abundant data and the Bray-Curtis similarity coefficient were used for One-way PERMANOVA and SIMPER. The relationship between the inland sandy area of Hai Lang and the coastal sandy areas in Quang Tri province, in terms of species composition (presence-absence data) using the Jaccard similarity coefficient, was assessed through cluster analysis (UPGMA). In addition, cluster analysis was also used to evaluate the close relationship of community structure among habitats, using data on species abundance and the Bray-Curtis similarity coefficient. Species richness and Simpson diversity (1-D) were used to assess the diversity among habitats. The mean values of diversity indices among habitats were compared using one-way ANOVA post-hoc Tukey test. The 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 and phytogeography

In the natural vegetation of the study area, a total of 91 species of trees and shrubs were identified, belonging to 69 genera and 37 families. The family with the largest number of recorded species was Myrtaceae with 11 species, followed by Rubiaceae (8 species), Phyllanthaceae and Lauraceae (each with 7 species), Myrsinaceae (6 species), and Rutaceae (4 species). There were 5 families of plants, each with 3 species (Annonaceae, Fagaceae, Moraceae, Sapindaceae, Apocynaceae), and 7 families with 2 species each (Clusiaceae, Sterculiaceae, Euphorbiaceae, Melastomataceae, Fabaceae, Aquifoliaceae, Verbenaceae). The remaining families consisted of only 1 species each. The genus *Syzygium* had the highest number of species with 7, followed by *Ficus* and *Ardisia*, each with 3 species. Furthermore, there were 12 genera with 2 species each, and 54 genera with 1 species each (Table 1).

Out of the total of 91 species recorded, 51 were shrubs and 40 were trees. The majority of tree species belonged to the Myrtaceae family (7 species), followed by Lauraceae (5 species), Myrsinaceae and Fagaceae (3 species each). Additionally, there were 3 families with 2 tree species each (Clusiaceae, Aquifoliaceae, and Rutaceae). The remaining families each had only 1 tree species (Table 1).

The natural vegetation consisted of 11 plant geographical elements, encompassing 83 species (91.22%), and 8 remaining species had not been attributed to a specific plant geographical element (8.79%). Indochinese element has the largest number of species, including 20 species, accounting for 21.98%, followed by Endemic element (17 species, 18.68%), Tropical Asian element (16 species, 17.58%), Indian element (12 species, 13.19%). The remaining factors had 18 species, accounting for 19.79%. (Table 1).

Table 1: Species composition, life forms, habitats, and phytogeographic elements of trees and shrubs in the inland sandy area of Hai Lang. Which: HSD - Humid stable dunes, ASD - Arid stable dunes, WL - Wetlands

Taxa	Habits	Habitats	Phytogeographic Elements
MAGNOLIOPSIDA			
Anacardiaceae			
Gluta wrayi King.	Tree	HSD, ASD	Malaysian element
Annonaceae			
Meiogyne hainanensis (Merr.) Tien Ban	Shrub	HSD, ASD	Indochinese Element
Polyalthia suberosa (Roxb.) Thw.	Shrub	ASD	Asian element
Xylopia vielana Pierre ex Fin. & Gagn.	Tree	ASD	Indochinese Element
Aquifoliaceae			
Ilex brevicuspis Reiss.	Tree	HSD, ASD	Undefined
Ilex cymosa Bl.	Tree	ASD	Endemic Element
Apocynaceae			
Strophanthus divaricatus (Lour.) Hook. & Arn.	Shrub	ASD	Indochinese Element
Tabernaemontana crispa Roxb.	Shrub	HSD, ASD	Endemic Element
Tabernaemontana buffalina Lour.	Shrub	HSD, ASD	Endemic Element
Celastraceae			
Euonymus laxiflorus Champ. in B.&H.	Shrub	HSD	Indian element
Clusiaceae			
Garcinia cowa Roxb.	Tree	HSD, ASD	Indochinese Element
Garcinia ferrea Pierre	Tree	HSD, ASD	Indochinese Element
Elaeocarpaceae			
Elaeocarpus tonkinensis A. DC.	Tree	HSD	Endemic Element
Ericaceae			
Vaccinium bracteatum Thunb.	Shrub	ASD	Asian element

Taxa	Habits	Habitats	Phytogeographic Elements
Euphorbiaceae			
Croton heteocarpus Mull. Arg.	Shrub	HSD, ASD	Indonesian-Malaysian element
Briedelia monoica (Lour.) Merr.	Tree	HSD, ASD	Tropical Asian element
Fabaceae			
Ormosia henryi Prain	Shrub	HSD, ASD	South China Element
Archidendron bauchei (Gagnep.) I.C. Niels.	Tree	HSD, ASD	Indochinese Element
Fagaceae			
Castanopsis indica (Rox. ex Lindl) A. DC.	Tree	HSD, ASD	Indian element
Lithocarpus sabulicolus Hick.	Tree	HSD, ASD	Endemic Element
Lithocarpus concentricus (Lour.) Hjelmq.	Tree	HSD, ASD	Endemic Element
Flacourtiaceae			
Homalium cochinchinensis (Lour.) Druce.	Tree	ASD	Endemic Element
Icacinaceae			
Gonocaryum lobbianum (Miers) Kurz.	Tree	HSD	Indochinese Element
Lauraceae			
Litsea glutinosa (Lour.) C. B. Rob.	Tree	HSD, ASD	Tropical Asian element
Litsea brevipes Kost.	Tree	ASD	Endemic Element
Actinodaphne pilosa (Lour.) Merr.	Tree	HSD, ASD	South China Element
Cinnamomum burmannii (Ness et. T. Nees) Blume	Tree	HSD, ASD	Indonesian-Malaysian element
Cinnamomum melastomaceum Kost.	Tree	HSD, ASD	Endemic Element
Lindera myrrha (Lour.) Merr.	Shrub	ASD	Endemic Element
Neolitsea merrilliana C.K. Allen	Shrub	HSD, ASD	South China Element
Lecythidaceae			
Barringtonia acutangula (L.) Gaertn.	Tree	WL	Indochinese Element
Malvaceae			
Hibiscus tiliaceus L.	Tree	WL	Tropical Asian element
Melastomataceae			
Melastoma affine D. Don	Shrub	ASD, WL	Tropical Asian element
Osbeckia stellata Buchanan-Hamilton ex Kew Gawler	Shrub	ASD, WL	Indochinese Element
Memecylaceae			
Memecylon umbellatum Burm. F.	Tree	ASD	Endemic Element
Moraceae			
Ficus simplicissima Lour.	Shrub	ASD	Tropical Asian element
Ficus fulva Reinw. ex Bl.	Shrub	ASD	Tropical Asian element
Ficus benjamina L.	Tree	WL	Undefined
Myrsinaceae			
Ardisia splendens Pit.	Shrub	HSD, ASD	Endemic Element
Ardisia dipressa C.B.Cl.	Shrub	HSD	Tropical Asian element
Ardisia crenata Sims.	Shrub	ASD	Tropical Asian element
Rapanea linearis (Lour.) Moore.	Tree	HSD, ASD	South China Element
Embelia picta A. DC.	Tree	ASD	Indian element
Embelia henryi Walker.	Tree	ASD	South China Element

Taxa	Habits	Habitats	Phytogeographic Elements
Myrtaceae			
Baeckea frutescens L.	Shrub	ASD, WL	Indian element
Melaleuca cajuputi Pow.	Tree	WL	Indochinese Element
Rhodomyrtus tomentosa (Ait.) Hassk.	Shrub	ASD	Tropical Asian element
Rhodamnia dumetorum (DC.) Merr.& L. M. Perry	Tree	ASD	Indochinese Element
Syzygium lineatum (DC.) Merr.& L. M. Perry	Tree	ASD	Indian element
Syzygium odoratum (Lour.) DC.	Shrub	ASD	Indochinese Element
Syzygium corticosum (Lour.) Merr. & Perry	Tree	HSD, ASD	Undefined
Syzygium grande (Wight.) Walp.	Tree	ASD	Indian element
Syzygium zeylanicum (L.) DC.	Tree	HSD, ASD	Indian element
Syzygium mekongensis (Gagn.) Merr. Perry	Tree	ASD	Indochinese Element
Syzygium bullockii (Hanc.) Merr. & L.M. Perry	Shrub	HSD, ASD	Hainan-Taiwan-Philippines element
Oleaceae			
Olea dioica Robx	Shrub	HSD, ASD	Indian element
Phyllanthaceae			
Breynia glauca Craib.	Shrub	ASD	Indochinese Element
Breynia ruticosa (L.) Hook. F.	Shrub	ASD	Tropical Asian element
Cleistanthus pierrei (Gagn.) Croiz.	Shrub	HSD, ASD	Endemic Element
Phyllanthus thaii Thin.	Shrub	ASD	Endemic Element
Phyllanthus fasciculatus (Lour.) Mull.Arg.	Shrub	ASD	Undefined
Aporosa dioica (Robx.) Muell.-Arg	Tree	HSD, ASD	Malaysian element
Antidesma rugosa (Lour.) Mull. Arg.	Shrub	HSD, ASD	Tropical Asian element
Rhizophoraceae			
Carallia brachiata(Lour.) Merr.	Tree	HSD, ASD	Malaysian element
Rosaceae			
Rhaphiolepis indica (L.) Lindl. ex Ker.	Tree	ASD	Hainan-Taiwan-Philippines element
Rubiaceae			
Fagerlindia scandens (Thunb.) Tirveng.	Shrub	HSD, ASD	Indochinese Element
Gardenia angusta (L.) Merr.	Shrub	WL	South China Element
Ixora coccinea L.	Shrub	HSD, ASD	Indochinese Element
Ixora duffii T. Moore	Shrub	ASD	Undefined
Pavetta cambodiensis Brem.	Shrub	HSD, ASD	Indochinese Element
Psychotria rubra (Lour.) Poir.	Shrub	HSD, ASD	Indian element
Psychotria montana Blume	Shrub	ASD	Tropical Asian element
Psydrax umbellata (Wight) Bridson	Shrub	ASD	Indian element
Rutaceae			
Acronychia pedunculata (L.)Miq.	Tree	HSD, ASD	Tropical Asian element
Euodia lepta (Spreng.) Merr.	Tree	WL	Indian element
Glycosmis pentaphylla (L.) Tan.	Shrub	HSD	Tropical Asian element
Severinia monophylla (L.) Tan.	Shrub	ASD	Tropical Asian element
Sapindaceae			
Dodonaea angustifolia L. f.	Shrub	ASD	Ancient tropical element
Mischocarpus poilane Gagn.	Tree	HSD, ASD	Undefined
Allophylus cochinchinensis Pierre.	Shrub	HSD	Undefined

Taxa	Habits	Habitats	Phytogeographic Elements
Simaroubaceae			
Eurycoma longifolia Jack.	Shrub	HSD, ASD	Indochinese Element
Sterculiaceae			
Sterculia lanceolata Cav.	Tree	ASD	Hainan-Taiwan-Philippines element
Melochia corchorifolia L.	Shrub	ASD	Tropical Asian element
Theaceae			
Camellia sinensis (L.) Kuntze	Shrub	ASD	Wide distribution element
Thymelaeaceae			
Wikstroemia indica (L.) C. A. Mey.	Shrub	ASD	Endemic Element
Ulmaceae			
Trema tomentosa (Robs.) Hara	Shrub	ASD	Indian element
Verbenaceae			
Clerodendrum lanessanii Dop	Shrub	ASD	Endemic Element
Clerodendrum robinsonii Dop	Shrub	ASD	Endemic Element
LILIOPSIDA			
Arecaceae			
Rhapis micrantha Becc.	Shrub	HSD, ASD	Indochinese Element
Pandanaceae			
Pandanus tectorius Parkinson ex Zucc.	Shrub	HSD, ASD, WL	Undefined
Poaceae			
Bambusa bambos (L.) Voss	Shrub	ASD	Indochinese Element

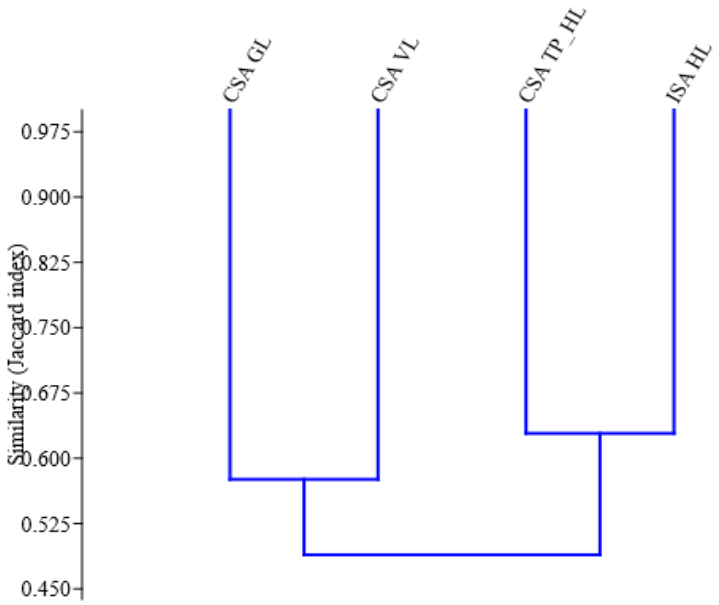

Figure 2: Dendrogram based on the paired group (UPGMA) using similarity Jaccard index for clustering of four sandy areas of Quang Tri province. Which: ISA HL – Inland sandy area in Hai Lang, CSA TP-LH – Coastal sandy area in Trieu Phong and Hai Lang, CSA GL – Coastal sandy area in Gio Linh, CSA VL – Coastal sandy area in Vinh Linh.

In the sandy coastal area of Quang Tri province, Myrtaceae, Rubiaceae, Phyllanthaceae, and Lauraceae had also been recorded as plant families with a predominance of tree and shrub species (Thao, 2020; Thao, 2022; Thao and Co, 2023). Therefore, it can be concluded that these plant families are dominant in the sandy areas of Quang Tri province, including the coastal sandy area and the inland sandy area. The inland sandy area of Hai Lang does not have the presence of *Vitex rotundifolia*, a species commonly found in the mobile sandy area adjacent to the coast. The species composition of the Hai Lang inland sandy area was more closely related to the Trieu Phong – Hai Lang coastal sandy area, while the Gio Linh and Vinh Linh coastal sandy areas exhibited greater similarity to each other (Cophenetic correlation = 0.6924) (Figure 2). Out of the 91 species recorded in the Hai Lang inland sandy area, 65 species were also found in the Trieu Phong – Hai Lang coastal sandy area, 49 species in the Gio Linh coastal sandy area, 48 species in the Vinh Linh coastal sandy area, and 33 species in all four mentioned areas (Thao, 2020; Thao, 2022; Thao and Co, 2023). Moreover, several species of trees and shrubs in the Hai Lang inland sandy area were also documented in the Phong Dien inland sandy areas of Thua Thien Hue, Vietnam (Thao et al., 2015).

Assemblages of species

The results of the One-way PERMANOVA analysis indicated statistically significant differences in the composition and richness of species distribution among the three habitat types (p(PERMANOVA) = 0.0001, F = 11.65), as well as between different pairs of habitats: humid stable dunes - arid stable dunes (p = 0.0004, F = 2.894), humid stable dunes - wetlands (p = 0.0001, F = 7.489), and arid stable dunes - wetlands (p = 0.0001, F = 20.36) (Table 2). The SIMPER analysis results revealed that the total difference between plant communities in the three habitat types accounted for 94.44%, with 8 plant species contributing to 48.67% of this total difference (Table 3). Cluster analysis using the UPGMA method, based on the Bray-Curtis similarity coefficient, demonstrated a closer relationship between humid stable dunes and arid stable dunes in terms of plant community structure, compared to wetlands (Cophenetic correlation = 1) (Figure 3).

Table 2: Result of One – way PERMANOVA

	p	**F**
PERMANOVA	0.0001	11.65
Pairwise		
Humid stable dunes - Arid stable dunes	0.0004	2.894
Humid stable dunes - Wetlands	0.0001	7.489
Arid stable dunes - Wetlands	0.0001	20.36

Table 3: Result of SIMPER

Taxa	**Contribution %**	**Cumulative %**	**Mean Humid stable dunes**	**Mean Arid stable dunes**	**Mean Wetlands**
Croton heteocarpus	9.99	9.99	4.88	5.47	0
Euodia lepta	7.65	17.64	0	0	5.10
Melastoma affine	6.22	23.86	0	0.44	6.62
Osbeckia stellata	5.60	29.46	0	0.08	5.95
Cleistanthus pierrei	5.16	34.62	4.75	2.47	0
Melaleuca cajuputi	5.15	39.77	0	0	5.14
Neolitsea merrilliana	5.01	44.78	5.63	2.00	0
Ixora coccinea	3.90	48.68	3.50	1.54	0
Overall average dissimilarity = 94.44					

Out of the total of 91 species recorded, 6 species were exclusively found in wetlands, with *Melaleuca cajuputi*, *Gardenia angusta*, and *Euodia lepta* being dominant. In arid stable dunes, 38 species were identified, with *Lindera myrrha*, *Ardisia crenata*, and *Psydrax umbellata* being the dominant species. Furthermore, 6 species were exclusively distributed in humid stable dunes, with *Allophylus cochinchinensis* being the dominant species. In addition to the species recorded as exclusively distributed in a single habitat type, there were also species with wide distribution. Thirty-seven species were distributed in both humid stable dunes and arid stable dunes, with *Gluta wrayi*, *Croton heteocarpus*, *Lithocarpus concentricus*, *Neolitsea merrilliana*, *Syzygium zeylanicum*, *Cleistanthus pierrei*, *Antidesma rugosa*, *Ixora coccinea*, *Psychotria rubra*, and *Mischocarpus poilane* being the dominant species. Three species were distributed in both arid stable dunes and wetlands, with *Melastoma affine* and *Osbeckia stellata* being dominant. *Pandanus tectorius* was distributed across all habitat types (Table 1).

The structure of tree and shrub plant communities varied among the three habitat types, indicating the influence of habitat on community structure. These differences in the structure of tree and shrub plant communities in the inland sandy area were similar to those found in previous studies in coastal sandy areas of Quang Tri province (Thao, 2020; Thao, 2022). The difference in community structure is caused by significant differences in physical environment (Maun, 2009). Soil moisture content is one of the factors affecting sand dune systems (Kutiel et al., 2016). In sand dune ecosystems, soil moisture plays a critical limiting role in plant survival, affects the development of individual plant species, and limits the distribution patterns of many species (Lamont et al., 1989; Long et al., 2011). In addition, differences in vegetation cover relate to nutrient content and soil moisture (Lima, 1981). The relative distance to water sources can also affect the composition and distribution of woody plant communities due to changes in available water for growth (Marod et al., 1999; Scalley et al., 2009; Sarvade et al., 2016; Navakam et al., 2017).

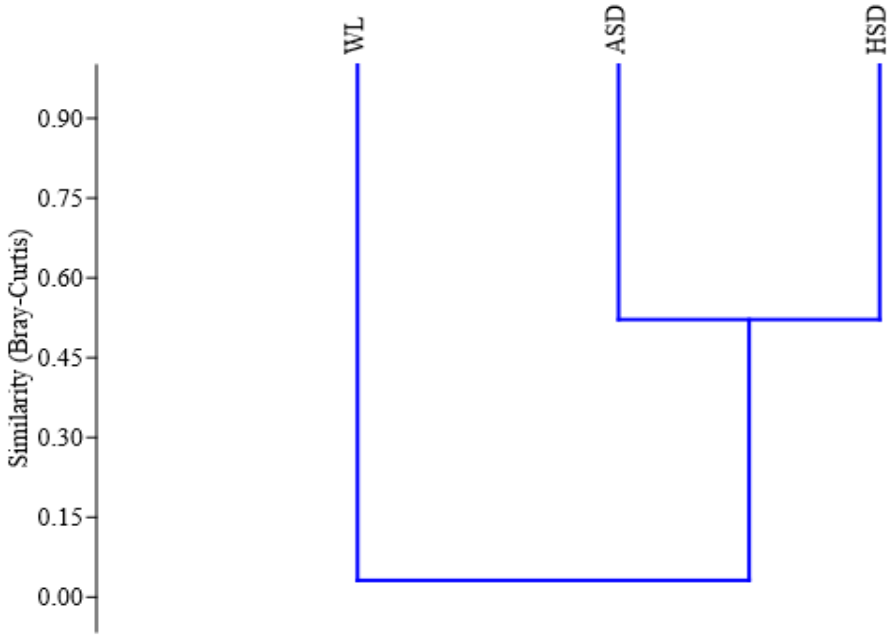

Figure 3: Dendrogram based on the paired group (UPGMA) using similarity Bray-Curtis index for clustering of three types of habitats. Which: HSD - Humid stable dunes, ASD - Arid stable dunes, WL - Wetlands.

The Diversity indices

The diversity index for the three habitat types is shown in Table 4. Arid stable dunes had a high total number of species at 79, with an average species richness of 10.19 per quadrat, and the number of species per quadrat ranging from 3-20. Humid stable dunes had a total of 44 species, but the average species richness

was the highest at 13.25 species, and the number of species per quadrat ranged at a high level from 10-17. Wetlands had low species richness with only 10 species, an average of 2.71 species per quadrat, and the number of species per quadrat ranging from 1-5. The Simpson diversity index in arid stable dunes was 0.9446, and the diversity index in each quadrat ranged from 0.4995 to 0.9256, with an average of 0.8154 per quadrat. The diversity index in humid stable dunes was 0.9433, and the diversity index in each quadrat ranged from 0.8527 to 0.8960, with an average of 0.8740, which was the highest among the habitat types. The diversity index in wetlands was lower than that in other habitat types, with a diversity index of 0.8015, ranging from 0-0.7161 per quadrat, and an average of only 0.4434. The diversity and species richness between different habitat types were statistically significant except for the diversity index between humid stable dunes and arid stable dunes which was not statistically significant (Table 5).

Table 4: The diversity index of three types of habitats

Habitats	**Number of quadrats**	**Species richness**			**Simpson index**		
		Pool of quadrat	Average of quadrat	Range of quadrat	Pool of quadrat	Average of quadrat	Range of quadrat
Arid Stable Dunes	94	79	10.19	3-20	0.9446	0.8154	0.4995 - 0.9256
Humid Stable Dunes	8	44	13.25	10-17	0.9433	0.8740	0.8527 - 0.8960
Wetlands	21	10	2.71	1-5	0.8015	0.4434	0 - 0.7161
Overall Vegetations	123	91	9.11	1-20	0.9560	0.7557	0 - 0.9256

Table 5: Result of ANOVA, post hoc test Tukey

Habitats	**Diversity indices**	**Mean Difference**	**p**
Humid stable dunes - Arid stable dunes	Species richness	3.05851	0.010
	Simpson index	0.05860	0.359
Arid stable dunes - Wetlands	Species richness	7.47720	0.000
	Simpson index	0.37206	0.000
Humid stable dunes - Wetlands	Species richness	10.53571	0.000
	Simpson index	0.43066	0.000

In the Hai Lang inland sandy area, the species richness and Simpson diversity in the habitat of wetlands were lower than those in the humid stable dunes and arid stable dunes. This result was consistent with a study conducted in the coastal sandy area of Quang Tri province. The species richness and Simpson diversity of plants distributed in wetlands were also lower than those in unflooded stable dunes, as observed in the sandy area of Gio Linh, Trieu Phong-Hai Lang coastal area (Thao, 2020; Thao, 2022). Another study found that the species richness of woody and herbaceous plants in plant communities decreased as flooding increased in the Neotropical savanna (de Oliveira Xavier et al., 2019). The waterlogged environment depleted oxygen and accumulated carbon dioxide in the soil, adversely affecting the distribution of many woody plant species by inhibiting seed germination, nutrient, and reproductive development, altering plant anatomy, and causing plant death (Kozlowski, 1997).

CONCLUSION

The study identified the species composition of tree and shrub plants in the inland sandy area of Hai Lang and determined the dominant species at the study site. The diversity of vegetation was quite high, and the

diversity of plant communities among different habitat types was evident. The research aimed to provide necessary scientific information for the conservation and restoration of vegetation cover at the study site.

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