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SPECIES COMPOSITION AND DIVERSITY OF MANGROVE COMMUNITIES ASSOCIATED WITH *Lumnitzera littorea* IN SOUTHERN VIETNAM

Quach Van Toan Em[1], Vien Ngoc Nam[2], Ngo Xuan Quang[3,4,*]

[1]Ho Chi Minh City University of Education, Ho Chi Minh City, Vietnam
[2]Nong Lam University, Ho Chi Minh City, Vietnam
[3]Institute of Life Sciences, Vietnam Academy of Science and Technology, Ho Chi Minh City, Vietnam
[4]Graduate University of Science and Technology, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Ha Noi, Vietnam

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ABSTRACT

Mangroves are among the world's most threatened ecosystems, with approximately 50% of the global mangrove area lost since 1900 and 35% lost in the past two decades. This study assessed the species composition and diversity of mangrove communities in southern Vietnam. Plant species were identified and measured using a plot method, with 10 m × 10 m plots established at three different sampling sites. A total of 15 plant species were recorded, including 13 true mangrove species and two associated species. Among these, *Aegiceras floridum* R. & Sch. is listed as Near Threatened by the IUCN, while *Lumnitzera littorea* is classified as Vulnerable in the Vietnam Red Data Book. In areas where *L. littorea* is dominant, diversity indices were low, with uneven species distribution across plots. The highest diversity was recorded on Con Dao Island, and the lowest on Phu Quoc Island. Our findings suggest that to conserve and protect high-diversity *L. littorea* communities, they should be planted together with *Ceriops tagal* or *Rhizophora apiculata*, given the high similarity coefficient (> 0.5) among these species.

Keywords: Composition, Can Gio, Con Dao, diversity, *Lumnitzera littorea*, mangrove communities, Phu Quoc.

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[*]*Corresponding author email*: ngoxuanq@gmail.com

INTRODUCTION

Mangroves are transitional ecosystems found in tropical and subtropical coastal estuaries, straddling marine and terrestrial environments. Globally, mangroves exhibit considerable diversity, with approximately 70 species belonging to 17 families. Compared to other forest types, mangroves tend to be structurally uniform but often display distinct zonation patterns shaped by gradients in elevation, salinity, and wave exposure (Tomlinson, 1986; Saenger, 2002). In primary Southeast Asian mangrove forests, species are typically distributed across three main zones: the *Avicennia-Sonneratia* zone, the *Bruguiera-Rhizophora* zone, and the back-mangrove zone (Watson, 1928).

Mangrove forests play a vital role in coastal protection, mitigating erosion and buffering against storms. Their extensive above-ground root systems and dense stands can form effective physical barriers against tidal energy. Furthermore, mangroves serve as critical habitats for a wide variety of terrestrial, estuarine, and marine organisms (Saenger, 2012; Hogarth, 2007; Ellison, 2008; Nagelkerken et al., 2008). With the growth of ecotourism, mangroves are now also valued as sites for tourism and environmental education (Pham Hoang Ho, 1985; Phan Nguyen Hong et al., 1999; Quach Van Toan Em et al., 2010; Tran Thi Thuy Van et al., 2017).

However, mangrove extent has declined rapidly worldwide due largely to human activities, especially conversion to aquaculture and agriculture. According to Phan Nguyen Hong et al. (1999), mangrove loss has accelerated in many regions under economic pressure, population growth, and limited conservation awareness. A global IUCN Red List assessment indicates that 11 of the 70 mangrove species (16%) are threatened, with up to 40% of species threatened along the Atlantic and Pacific coasts of Central America. While *Lumnitzera littorea* is classified as Least Concern (LC) globally by the IUCN (Anon, 2022), it is listed as Vulnerable (VU) in the Vietnam Red Book (Vietnam Academy of Science and Technology, 2024) among Vietnam’s 37 key mangrove species.

This species typically inhabits estuarine and coastal mangrove areas with limited saltwater intrusion and compact clay soils, generally under tidal influence. It is often associated with species such as *Excoecaria agallocha* and *Ceriops* spp., sometimes forming dominant or nearly pure stands (Quy et al., 2005).

Currently, *L. littorea* populations are mainly concentrated in Can Gio (Ho Chi Minh City), Phu Quoc (Kien Giang), and Con Dao (Ba Ria–Vung Tau), with additional occurrences in areas such as Cam Ranh (Khanh Hoa), Ha Tien (Kien Giang), and Dong Nai. In recent years, due to increased attention from researchers, conservationists, and governmental agencies, the remaining populations have received better protection. Nevertheless, information on their ecology, community structure, and diversity remains limited. Therefore, this study aims to assess the species composition and diversity of mangrove communities associated with *L. littorea* in southern Vietnam.

MATERIALS AND METHODS

Study sites. Study sites were located in Sub-Area 4 (10°32’15.18”N and 106°58’39.55”E), Sub-Area 7 (10°32’29.44”N and 106°55’52.64”E), and Sub-Area 14 (10°33’57.22”N and 106°53’24.66”E) of the Can Gio Mangrove Biosphere Reserve; Hon Ba Island in Con Dao National Park (8°38’52”N and 106°33’6”E); and Rach Tram River in Phu Quoc National Park (10°14’33.57”N and 103°58’52.24”E) (Fig. 1).

Sampling Design. The structural data of *L. littorea* communities were collected from 10 m × 10 m measurement plots established using the method of English (1997). The survey was conducted in three areas (Fig. 1) with a total of 20 plots established: 7 plots in three sub-areas of Can Gio, 3 plots in one location of Con Dao, and 10 plots in two areas of Phu Quoc.

Figure 1. Location of three study sites with a concentrated distribution of *Lumnitzera littoreain* in Southern Vietnam (Google Earth, 2020)

Data collection. The plots were established and arranged to represent the survey communities. In each plot, the following information was collected:

The plant species names were determined based on the guide to mangrove biodiversity investigation and research (plant part) of Phan Nguyen Hong & Hoang Thi San (1993), FAO (2003), Anderson et al. (2012). The diameter breast-high (DBH) was measured using a tape measure. The species composition and number of individuals of each species were identified and recorded (Snedaker & Snedaker, 1984; Joshi & Ghose, 2014; Cañizares & Seronay, 2016; Winata et al., 2017).

Data analysis. Determination of relative values such as Relative occurrence frequency (RF), relative density (RD), and relative coverage (RC) were determined (Rastogi, 1999; Sharma, 2009). The Important Value Index (IVI - Importance Value Index) of each species was determined according to the following formula: IVI = RD + RF + RC (RD: relative density; RF: relative occurrence frequency; RC: relative coverage) (Rastogi, 1999; Sharma, 2009). Similarity Index (SI) (Vietnam Academy of Science and Technology, 2024): species composition between study sites was determined using the formula $SI = 2C/(A+B)$, where C is the number of species occurring in both areas A and B, A is the number of species in area A, and B is the number of species in area B (Shannon & Wiene, 1963). The similarity index Bray-Curtis was also used to identify a significant similarity group. Biodiversity Pro 2.0 statistical software was used to determine biodiversity indices, such as: Species diversity Margalef (d); Pielou uniformity (J'); Shannon-Weiner index (H'); Simpson Dominance Index (D).

RESULTS

Species composition of the *Lumnitzera littorea* communities distributed in Southern Vietnam

A total of 15 plant species were recorded in the survey of 20 plots in 3 study areas (Table 1, Fig. 2). These included 13 true mangrove species and 2 mangrove associate species (*Melaleuca cajuputi* and *Thespesia populnea*) from 9 families and 12 genera in the *L. littorea* tree communities distributed in Southern Vietnam. The Rhizophoraceae family contributes the highest number of species (6 species), followed by the Combretaceae family with 2 species, and the rest of each family has only 1 species. The highest number of mangrove species was found in Phu Quoc (9 species), followed by Can Gio (7 species) and Con Dao (5 species). *L. littorea* accounted for the highest proportion of species (28.94%), followed by *Rhizophora apiculata* (18.02%). The species contributes the lowest occurrence was *Lumnitzera racemose*, with only one individual found in Can Gio (plot 2), accounting for 0.17%. *Xylocarpus granatum* and *T. populnea* had 2 individuals each in Phu Quoc (plots 7 and 8) at a rate of 0.35%, while *Sonneratia alba* had 4 individuals in Can Gio (plots 4 and 7) at a rate of 0.69%.

All 15 species recorded in the sampling sites are listed on the IUCN Red List. The species *Aegiceras floridum* R. & Sch. is classified as Near Threatened (NT), while the other 14 species are classified as Least Concern (LC). In addition, species *L. littorea* (Jack.) Voigt. is classified as Vulnerable (VU) according to the Vietnam Red Book (Table 1).

Table 1. Species composition of mangrove vegetation in the different sampling sites

No.	Scientific name	Family name	Status IUCN/ Vietnam Red Book	Sampling sites		
				Can Gio	Con Dao	Phu Quoc
		Avicenniaceae				
1	*Avicennia officinalis* L.		LC	x	-	-
		Combretaceae				
2	*Lumnitzera littorea* (Jack) Voigt		LC/VU	x	x	x
3	*Lumnitzera racemosa* Willd.		LC	x	-	-
		Euphorbiaceae				
4	*Excoecaria agallocha* L.		LC	-	-	x
		Malvaceae				
5	*Thespesia populnea* L.		LC	-	-	x
		Meliaceae				
6	*Xylocarpus granatum* Koen.		LC	-	-	x
		Myrsinaceae				
7	*Aegiceras floridum* R. & Sch.		NT	x	x	-
		Myrtaceae				
8	*Melaleuca cajuputi* Pwell.		LC	-	-	x
		Rhizophoraceae				
9	*Bruguiera gymnorrhiza* (L.) Lamk.		LC	-	x	x
10	*Bruguiera sexangula* (Lour.) Poir.		LC	-	-	x
11	*Ceriops tagal* (Perr.) CB Rob.		LC	x	x	-
12	*Kandelia candel* (L.) Druce.		LC	-	-	x
13	*Rhizophora apiculata* Blume.		LC	x	-	x
14	*Rhizophora stylosa* Griff.		LC	-	x	-
		Sonneratiaceae				
15	*Sonneratia alba* J.E. Smith.		LC	x	-	-
Total				7	5	9

Note: (-) does not appear (x) does appear (IUCN -https://www.iucnredlist.org/).

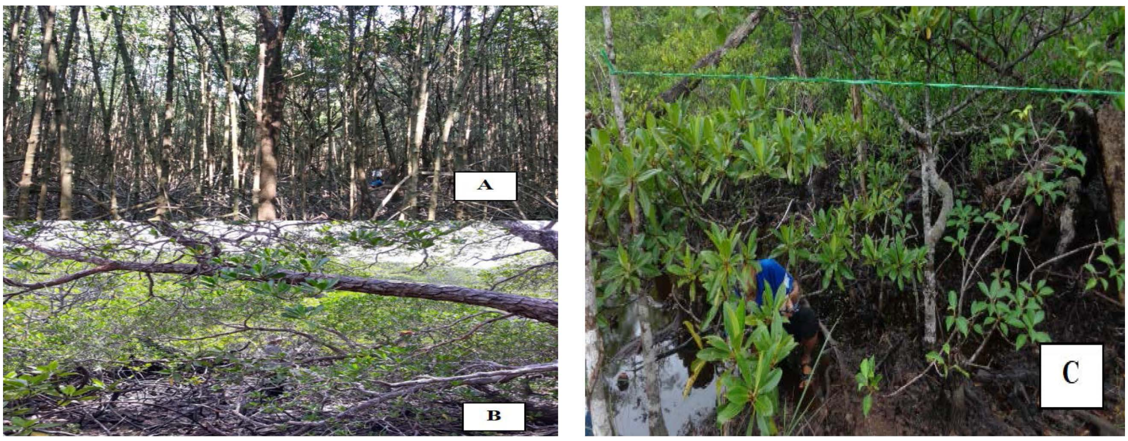

Figure 2. Habitat of mangrove in the study sites in Can Gio (A), Con Dao (B) and Phu Quoc (C)

The similarity of true mangrove communities distributed in Southern Vietnam

The results indicate relatively low similarity in the composition of true mangrove species among the sites (SI ≤ 0.5). This could be explained by the fact that three study sites have distinct background characteristics (Table 2), which are typical of communities dominated by *L. littorea* species. The *L. littorea* communities in Can Gio are distributed in areas with clay soil, alluvial deposits, and a large vegetative belt. Meanwhile, in the Phu Quoc and Con Dao areas, mangrove communities are distributed on sandy and gravel substrates, which are poor in nutrients and a narrow belt of several tens of meters (Phu Quoc), interspersed with *M. cajuputi* or terrestrial biomes (Con Dao). Table 2 shows that the similarity between Can Gio and Con Dao is the highest, with only SI = 0.5, while the value between Can Gio and Phu Quoc is very low (SI = 0.29). This is geographically appropriate since Can Gio and Con Dao are located in the Southeast Sea, while Phu Quoc is in the Southwest Sea.

Table 2. The similarity of true mangrove communities in the different sampling sites

Index SI (%)	Can Gio	Con Dao	Phu Quoc
Can Gio	1	0.50	0.29
Con Dao	-	1	0.33
Phu Quoc	-	-	1

Biodiversity indicators of the *Lumnitzera littorea* communities distributed in Southern Vietnam

Frequency of appearance. The Figure 3 measuring species occurrence frequency of appearance indicates a large variation ranging from 5 to 100%, with an average of 27.33%. Six out of the fifteen species accounted for 40% of the frequency, namely *L. littorea*, *C. tagal*, *R. apiculata*, *E. agallocha*, and *M. cajuputi*, which were above the average frequency. In contrast, some species had a very low occurrence frequency (*L. racemosa*, *T. populnea*, *X. granatum*, *S. alba*, etc.) as they only appeared in one or two plots within an area.

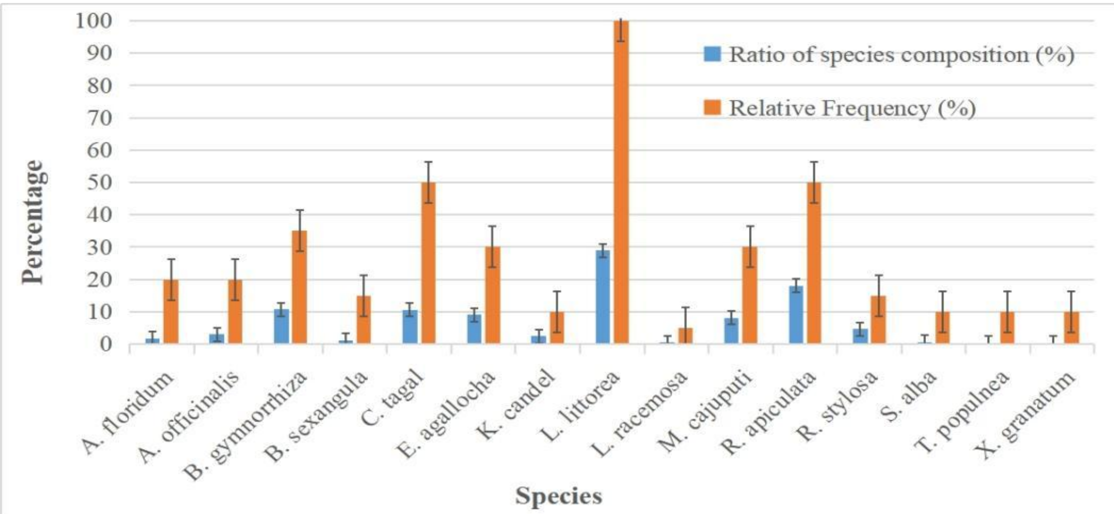

Figure 3. Average values and standard deviation of relative frequency and ratio of species composition in the different sites

Species composition. The number of species in each plot ranges from 2 to 6, with an average of 4.05 ± 1.36 species. Among them, there are 8 plots (3/7 in Can Gio and 5/10 in Phu Quoc) with more species than the average, accounting for 40% of the total 20 plots. Conversely, all 3 plots in Con Dao have 4 species per plot (Fig. 3).

Population density. The number of individuals varied from 11 to 88 per plot, with an average of 28.8 ± 16.86 individuals per plot. Out of the 20 plots studied, 6 plots had an above-average number of individuals, accounting for 30%, while 14 plots had a below-average number of individuals, accounting for 70%. Thus, the results indicate a large variation in the number of individuals in the community across different sites, especially in Con Dao, where the average was only 17.67 ± 6.11 individuals per plot.

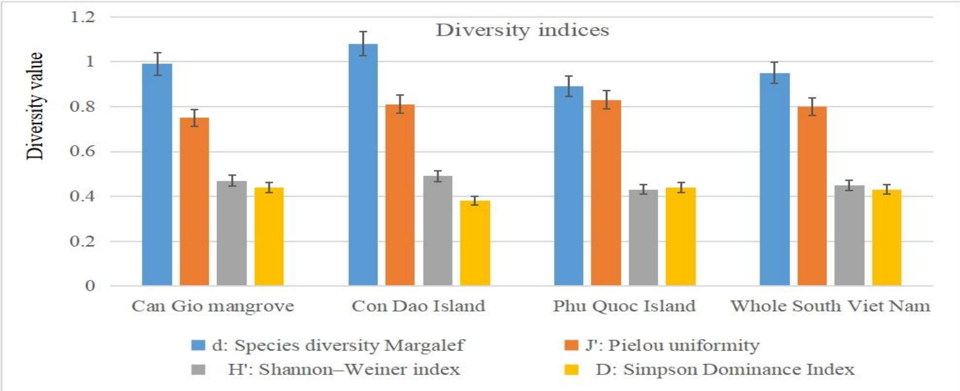

Figure 4. Average values and standard deviation of diversity indices of mangrove species in different sampling sites of Southern Vietnam

Margalef species diversity (d). In the plots, the average species diversity index was 0.95 ± 0.39. Of these, 66.67% were in two areas with a diversity index higher than the average, while 33.33% were accounted for by one area with a diversity index lower than the average. The species diversity index was highest in Con Dao (d = 1.08) and lowest in Phu Quoc (d = 0.89). These results indicate that the diversity index (d) in the study areas is relatively low (Fig. 4).

Pielou uniformity (J'). The Pielou uniformity ranged from 0.75 to 0.83, with an average of about 0.80 ± 0.19. Of these, 66.67% were in two plots with higher uniformity than the average, with the area with the highest average uniformity in the Phu Quoc area (J' = 0.83). The Can Gio area has the lowest uniformity (J' = 0.75). As the species composition and number of species in the three study areas differ, the uniformity also varies (Fig. 4).

Shannon-Wiener index (H'). The Shannon-Wiener index (H') fluctuated from 0.43 to 0.49, with an average of 0.45 ± 0.14. Two areas with a diversity index higher than the average accounted for 66.67% of the data. Among these, the Shannon diversity index was highest in Con Dao (H' = 0.49) and lowest in Phu Quoc (H' = 0.45) (Fig. 4).

Simpson Dominance Index (D). This index fluctuates between 0.38 and 0.44, with an average of 0.43 ± 0.15. In some areas of Can Gio and Phu Quoc, the dominance index (D) is higher than the average dominance index, accounting for 66.67% of the total. Conversely, in one area of Con Dao, the dominance index (D = 0.38) is smaller than the average dominance index, accounting for 33.33% (Fig. 4).

Importance index of species in the *Lumnitzera littorea* communities distributed in Southern Vietnam

The Importance Value Index (IVI%) is an indicator that represents the composition coefficient, importance, biodiversity, stability, and sustainability of an ecosystem. Essentially, the IVI index holds profound biological significance as it reflects the relationship between each tree species in a community and the community's relationship with natural conditions.

The results of the analysis of important indicators of species in the *L. littorea* community distributed in Southern Vietnam are shown in Table 3. The results indicate that *L. littorea* is the most important species, which is consistent with the research objectives of the topic, focusing on analyzing the ecological characteristics of the *L. littorea* community. Additionally, *R. apiculata* and *C. tagal* are two species with high importance indices after *L. littorea*. However, when analyzing different areas, the importance index of the species also varies.

Table 3. Important index of species in the *Lumnitzera littorea* communities distributed in Southern Vietnam

Species	IVI (% RD + % RF + % RBA)			
	Can Gio	Con Dao	Phu Quoc	Total
Aegiceras floridum	8.87	29.57	0	12.81
Avicennia officinalis	24.95	0	0	8.32
Bruguiera gymnorrhiza	0	10.31	55.71	22.01
Bruguiera sexangula	0	0	7.96	2.65
Ceriops tagal	51.48	40.68	0	30.72
Excoecaria agallocha	0	0	37.84	12.61
Kandelia candel	0	0	12.09	4.03
Lumnitzera littorea	92.33	132.11	120.09	114.84
Lumnitzera racemosa	7.57	0	0	2.52
Melaleuca cajuputi	0	0	47.90	15.97
Rhizophora apiculata	106.30	0	6.26	37.52
Rhizophora stylosa	0	87.33	0	29.11
Sonneratia alba	8.50	0	0	2.83
Thespesia populnea	0	0	6.02	2.01
Xylocarpus granatum	0	0	6.12	2.04

Importance index of species in the *Lumnitzera littorea* community in Can Gio

The *L. littorea* community distributed in Can Gio has been surveyed for seven true mangrove species. Among them, *R. apiculata* is the species with the highest Importance Value Index (IVI = 106.3%), followed by *L. littorea* (IVI = 92.33%), while *S. alba* has the lowest IVI value (IVI = 8.49%). In general, the difference in the dominance of species is not significant, with *L. littorea* having higher dominance due to having the highest Relative Basal Area (RBA = 48.96%) and the highest Relative Frequency (RF = 21.43%). Therefore, this shows that *L. littorea* is a fairly dominant species, playing an important role in the mangrove community in Can Gio. These results are consistent with the research of Quach & Vien (2010), where the populations of *L. littorea* regenerate and grow well in *R. apiculata* mangroves planted from 1978−1991, and natural mangroves include mixed forest *A. officinalis*, *C. tagal*, and so on.

Important index of species in the *Lumnitzera littorea* community in Con Dao

The *L. littorea* community distributed in Con Dao has been surveyed for five true mangrove species. Among them, *L. littorea* is the species with the highest Importance Value Index (IVI = 132.11%), followed by *R. stylosa* (IVI = 87.33%), while *B. gymnorrhiza* has the lowest IVI value (IVI = 10.31%). In general, there is a significant difference in the dominance of the species, in which, species *L. littorea* has the highest level of dominance and overwhelmingly the remaining species, such as *C. tagal*, *A. floridum*, and *B. gymnorrhiza*, despite having an RBA index that accounts for 86.36% (> 50%) and an RF of 25%. This shows that *L. littorea* is the dominant species, playing an important role in the mangrove biome in Con Dao.

Important index of species in the *Lumnitzera littorea* community in Phu Quoc

L. littorea is the species with the highest Importance Value Index (IVI = 120.9%), followed by *B. gymnorrhiza* (IVI = 55.71%) and *M. cajuputi* (IVI = 47.90%), while *T. populnea* has the lowest IVI value (IVI = 6.02%). Generally, there is a significant difference in the dominance of the species, with *L. littorea* having the highest level of dominance and overwhelming the remaining species, such as *K. candel*, *B. sexangula*, *R. apiculata*, *T. populnea*, and *X. granatum*, due to its RF index, which is also the highest. Therefore, *L. littorea* is the dominant species, playing an important role in the mangrove biome in Rach Tram, Phu Quoc.

Communal relationship between the study areas in Southern Vietnam through the Bray-Curtis Cluster analysis

The hierarchical agglomerative cluster analysis for the presence or absence of plant species across sampling sites based on the group-average linking of Bray-Curtis similarity coefficients is shown in Figures 5 and 6. The figure demonstrates that the *L. littorea* communities in Can Gio and Con Dao have a higher similarity than the *L. littorea* community in Phu Quoc. This result is consistent with the analysis of diversity and species composition of *L. littorea* communities distributed in Southern Vietnam, where the *L. littorea* community in Phu Quoc has the highest diversity in species composition (9 species). Additionally, when analyzing the SI index, Can Gio and Con Dao have the highest similarity with only SI = 0.5, whereas the similarity between Can Gio and Phu Quoc is very low (SI = 0.29).

Based on the results of the correlation analysis between *L. littorea* communities distributed in Southern Vietnam, it is considered a basis for selecting a conservation plan for the *L. littorea* species in different areas depending on substrate characteristics, tidal inundation regime, and types of intercropping plants.

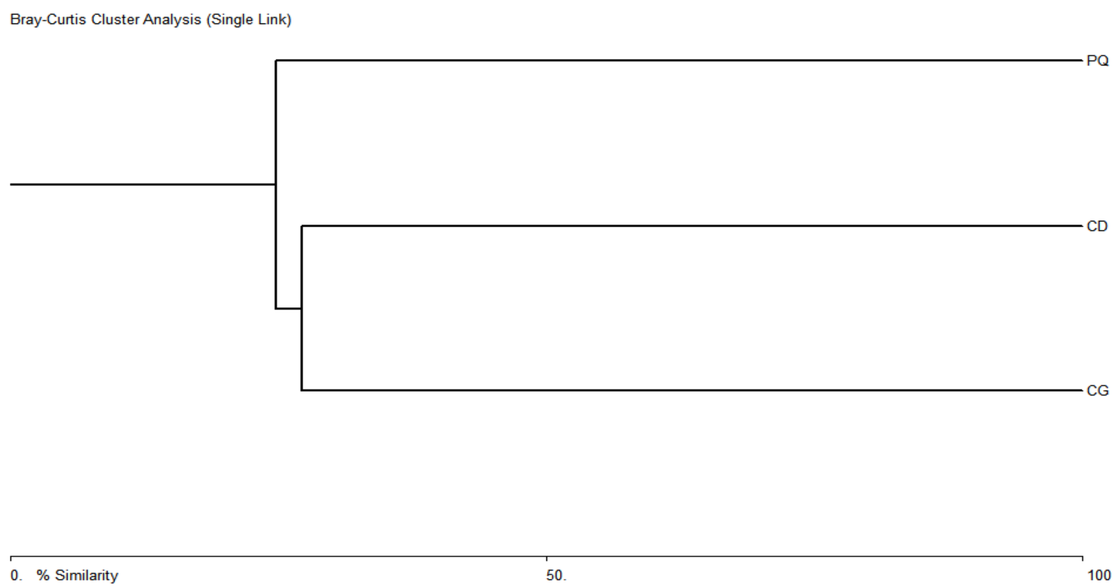

Figure 5. Dendrogram of three study sites per group-average linking of the Bray-Curis coefficient of similarity

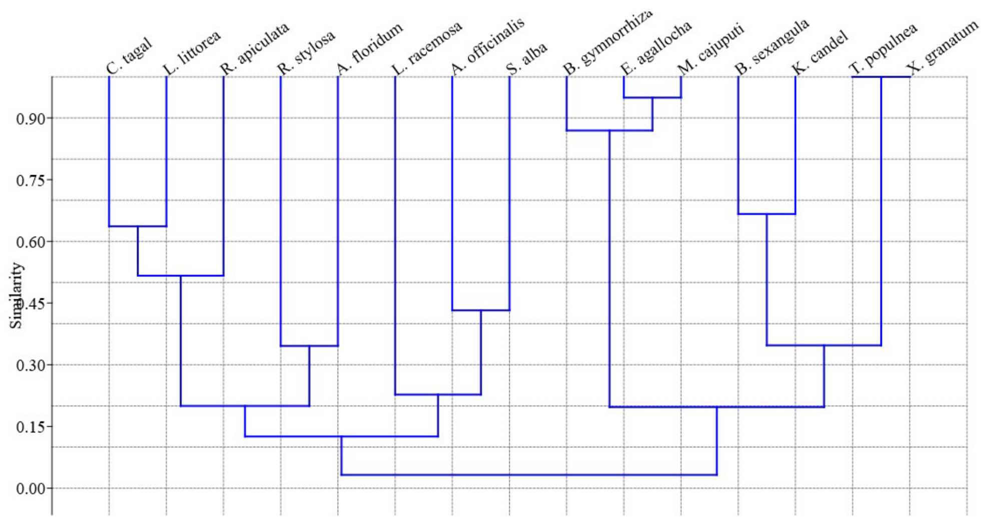

Figure 6. Dendrogram of hierarchical agglomerative cluster for the presence or absence of plant species in the different sampling sites based on group-average linking of the Bray-Curtis coefficient of similarity

DISCUSSION

According to Vien & Nguyen (1998), Vietnam's mangrove ecosystem is quite rich in plant species, including 37 true mangrove species and over 70 participating species within the mangrove forests. In the Can Gio mangrove forest, there are 35 true mangrove species and 29 salt-tolerant plant species. Recently, Pham et al. (2007) recorded 36 true mangrove species and 46 tree species participating in the mangrove ecosystem. Therefore, the species composition recorded in the studied *L. littorea* communities accounts for approximately 20% of the true mangrove species in Can Gio.

The Con Dao mangrove forest covers about 30 hectares, scattered across various areas. The largest area measures roughly 5.9 hectares, while the smallest is about 0.5 hectares. These mangrove habitats are mainly located on dead coral, sand, and gravel. Known as one of the few remaining primeval forests in Vietnam, the Con Dao mangrove harbor contains 23 true mangrove species and 18 participating species (Vien & Tran, 2008); other studies report 28 true mangrove species and 8 participating species (Kieu et al., 2012), or 24 true mangrove species and 9 participating species (Hoang, 2013). Thus, within the studied area, the recorded mangrove species represent only about 21.74% of the total species in the Dam Quat mangrove area.

In Phu Quoc National Park, Dang et al. (2011) surveyed 11 mangrove sites within four communities in the park, reporting a total of 23 true mangrove species. However, Hoang (2011) found the number of officially recognized mangrove species in this area to be lower-only 12 species, belonging to 6 mangrove plant families. Therefore, the species composition in the *L. littorea* communities studied accounts for approximately 58.33% of the actual mangrove species in Phu Quoc. However, there is no specific research focusing solely on *L. littorea* in this area.

Overall, the true and participating mangrove species in the three surveyed regions-including the concentrated distribution of *L. littorea*-reflect the typical species composition of Vietnamese mangrove forests, with the exception of *M. cajuputi* trees in Rach Tram River (Phu Quoc National Park). This species inhabits ecosystems on acidic flooded soils, representing a different ecological niche (Quach et al., 2022).

The species diversity index of mangrove communities in Southern Vietnam indicates a relatively stable or slightly disturbed state, requiring sustainable management and conservation efforts (Tran et al., 2017). The Pielou's evenness index (J=0.80) suggests an even distribution of mangrove species at the research sites (Manual et al., 2022). The dominance of *L. littorea*, as a result of restoration efforts, is rare for this species; in fact, mangrove rehabilitation projects in Southern Vietnam tend to focus more on promoting monocultures of species such as *L. littorea*, *Rhizophora*, and *Ceriops*, rather than increasing species diversity.

The biodiversity indices across the *L. littorea* communities in the southern regions show no significant differences. The analysis reveals a very strong negative correlation between the Simpson's dominance index (D) and the Shannon-Wiener diversity index (H') and evenness index (J')-with an R^2 of 98.48%. This indicates that a lower D-value corresponds to higher H' and J' values, and vice versa (Winata et al., 2017). Specifically, in Con Dao, the D-index was 0.38, and H' was 0.62, demonstrating the inverse relationship between the dominance and biodiversity indices.

Our study found that the groups of *Tectona populnea* and *Xylocarpus granatum*, as well as *M. cajuputi*, *Excoecaria agallocha*, and *B. gymnorrhiza*, are two clusters of species with close similarities, but they are distributed in different soil environments. The soil conditions for these groups are less flooded and were recorded randomly, which is markedly different from the other tree groups within the biome. Moreover, other mangrove groups, such as *K. candel* and *B. sexangula*, as well as *C. tagal* and *R. apiculata*, showed correlations with similar habitat conditions, with similarities ranging from more than 44.4% to 66.6%. The *S. alba* and *A. corniculatum* species, both of which inhabit soil conditions, display relatively low similarity. Additionally, *L. racemosa* and *R. stylosa* are two species with similar but low subgroupings, due to their random distribution within *L. littorea* communities. Interestingly, the figure also indicates that *L. littorea* clusters closely with *C. tagal* and *R. apiculata*, showing a relatively high similarity coefficient.

This suggests that no particular species dominate the area, and most of the species are evenly distributed across the sites. Such evenness directly influences ecosystem functions like process rates, as reflected in the diversity indices, and indirectly affects the relationship between process rates and species richness. The topography and soil type (edaphic factors) may partly explain the variation in species abundance and diversity across the study sites. Consequently, the areas host a diverse array of ecologically significant plant species that are disproportionally distributed over different locations (Lleno et al., 2023).

L. littorea grows in estuarine and coastal mangroves, usually only flooded during high tides or rarely during saltwater inundation, thriving on slightly compacted clay soils. It often coexists with species like *Ceriops* spp., *B. sexangula*, *B. gymnorrhiza*, *Excoecaria agallocha*, etc., sometimes forming dominant or near-monoculture stands with densities recorded in studies (Quach & Vien, 2010). Because these communities are distributed within a relatively narrow tidal regime, the species composition is usually limited to about 2–6 species, including both true and participating species. Consequently, the diversity index per sampling plot is relatively low compared to the overall biodiversity of mangrove forests. However, species distribution varies among sites, influenced by the physical and chemical properties of the soil.

In Can Gio, all three study areas possess clay loam soil with slightly acidic pH. The soil has high salinity levels and is rich in organic matter, total nitrogen, and readily available nitrogen forms. The organic matter mineralization rate (C/N ratio) is at a suitable level for mangrove growth, particularly supporting *L. littorea*. In contrast, the soils in Con Dao and Phu Quoc are sandy; the pH in Phu Quoc tends to be more acidic than in Can Gio and Con Dao. Salinity varies considerably across these locations, from moderate to high. The organic matter, total nitrogen, and available nitrogen contents are average to low, and the high mineralization rate results in poor humus accumulation-detrimental to mangrove regeneration (Quach et al., 2022).

In fact, mangrove species predominantly grow well on muddy, alluvial soils (Saenger, 2002; Watson, 1928; Ellison, 2008). In Southeast Asia, *Rhizophora mucronata* and *Avicennia marina* thrive in muddy habitats (Watson, 1928; Ellison, 2008). However, some species, such as *R. stylosa* and *R. mucronata*, can also survive on sandy soils, even on coral islands where the substrate contains coral debris, shells, and limestone residues (Ding Hou, 1958). Recorded mangrove trees on sandy soils, gravel, or mulch include *R. mucronata*, *C. tagal*, *R. apiculata*, *A. floridum*, and *B. gymnorrhiza* (Vien & Vuong, 2008; Kieu et al., 2012).

CONCLUSION

Our results on the composition and diversity of mangrove species in *Lumnitzera littorea* communities in Can Gio, Phu Quoc, and Con Dao showed that a total of 15 plant species were recorded, including 13 true mangrove species and 2 associated mangrove species. The biome in this area is characterized by two typical communities: one dominated by *L. littorea*, *Bruguiera gymnorrhiza*, and *Excoecaria agallocha*, and the other dominated by *L. littorea* and *Melaleuca cajuputi*. In terms of ecological structure, the diversity index in this area is relatively low, with an uneven distribution of species across the plots and a dominant population of *L. littorea*. Notably, the importance indices in both study areas indicate that *L. littorea* is the dominant species and plays a crucial role in these mangrove communities. It is essential to continue investigating the ecological factors, such as soil, water, and other environmental variables, that influence the distribution of *L. littorea*. Furthermore, understanding the ecological relationships between *L. littorea* populations and other plant species within the community is vital. Additionally, studying the ecological characteristics and regenerative capacity of natural *L. littorea* populations will support the development of conservation measures and sustainable management strategies for this rare plant species in the wild.

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