BENTHIC MACROINVERTEBRATES DIVERSITY IN THE TRA SU MELALEUCA FOREST LANDSCAPE PROTECTION AREA, AN GIANG PROVINCE, VIETNAM

LY, V. V.[1] – DINH, M. Q.[1*] – NGUYEN, T. K. T.[2] – VO, T. T. L.[1] – TRAN, N. A.[1] – NGUYEN, L. H. P.[1] – TRAN, T. T.[1] – LUU, T. L.[3] – NGUYEN, K.[3] – NGO, M. H.[3] – TRAN, S. N.[4] – NGUYEN, Q. V.[1]

[1]*Faculty of Biology Education, School of Education, Can Tho University, Ninh Kieu Ward, Can Tho 900000, Viet Nam*

[2]*Department of Biology, An Khanh High School, Ninh Kieu Ward, Can Tho 900000, Viet Nam*

[3]*World Wide Fund for Nature in Viet Nam, Nam Tu Liem Ward, Hanoi 100000, Viet Nam*

[4]*Department of Environmental Sciences, College of Environment and Natural Resources, Can Tho University, Ninh Kieu Ward, Can Tho 900000, Viet Nam*

[*]*Corresponding author*
e-mail: dmquang@ctu.edu.vn; phone: +84-9097-56705

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Abstract. Benthic macroinvertebrates play vital roles in freshwater ecosystems and are effective bioindicators of environmental health. This study examined species composition, density, and biodiversity indices of benthic fauna in the Tra Su Melaleuca Forest Landscape Protection Area, An Giang Province, Vietnam—a seasonally inundated wetland dominated by stagnant waters. Sampling (using a Petersen grab) was conducted at 15 sites during the wet (November 2024) and dry (March 2025) seasons. A total of 408 individuals representing 20 species from three phyla and four classes were recorded, with Mollusca contributing 80% of the species richness. Spatial patterns revealed that Area III, with greater hydrological connectivity, supported the highest biodiversity, whereas Area I showed markedly lower values. The invasive species *Pomacea canaliculata* was notably abundant, occurring at approximately 60% of sites with a density of 247 individuals/m², indicating potential ecological risks. Compared to previous studies, the observed increases in species richness and abundance suggest partial recovery of benthic communities. These findings provide updated baseline data to support long-term biodiversity monitoring and wetland management in the Mekong Delta.
Keywords: *benthic macroinvertebrates, biodiversity indices, Pomacea canaliculata, species composition, Tra Su Melaleuca Forest Landscape Protection Area*

Introduction

Wetland ecosystems in the Mekong Delta represent important ecological corridors, offering habitat to various aquatic and semi-aquatic species. The Tra Su Melaleuca Forest Landscape Protection Area (hereafter referred to as Tra Su Melaleuca Forest) in An Giang Province is a seasonally inundated wetland covering approximately 845 hectares. This forest is hydrologically regulated by an intricate dike system designed for flood control, resulting in extended flooding lasting up to 10 months annually. Dominated by *Melaleuca cajuputi*, the landscape supports a mosaic of shallow water bodies that host migratory birds, amphibians, reptiles, and fish. However, acid sulfate soils and seasonal fluctuations in pH and water quality—particularly during the dry season—challenge aquatic biodiversity and ecosystem function (Vietnam Association for Conservation of Nature and Environment, 2011).

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Benthic macroinvertebrates form a critical component of freshwater ecosystems, occupying the sediment-water interface of lakes, rivers, and wetlands. Taxonomically diverse, major benthic groups include annelids, mollusks, and crustaceans. Functionally, these organisms play essential roles in detritus breakdown, nutrient recycling, and sediment bioturbation. They also constitute a vital food resource for higher trophic levels, including fish and waterbirds. Due to their sedentary habits and sensitivity to environmental stressors, benthic fauna are widely recognized as effective bioindicators for assessing ecological integrity and monitoring anthropogenic impacts (Tagliapietra and Sigovini, 2010; Jana, 2024).

Despite the ecological importance of the Tra Su Melaleuca Forest, studies on its benthic fauna remain limited. Earlier assessments (e.g., Le et al., 2019) reported only 11 macroinvertebrate species, suggesting a decline from previously richer communities. While these studies confirmed the continued presence of major taxonomic groups—namely Mollusca, Annelida, and Arthropoda—the reduction in species richness raises concerns regarding habitat degradation and hydrological stress. This study aims to provide an updated assessment of benthic macroinvertebrate communities in the Tra Su Melaleuca Forest by investigating species composition, diversity indices, and spatial-seasonal variation. The results are expected to contribute to long-term ecological monitoring and inform conservation and management strategies in floodplain wetlands of the Mekong Delta.

Materials and methods

Sampling study and design

The study was conducted in the Tra Su Melaleuca Forest (An Giang Province, Vietnam) during two climatic periods: the wet season (November 2024) and the dry season (March 2025). A total of 15 sampling sites were selected across three ecological zones: Area I (administrative zone), Area II (strict protection zone), and Area III (ecological restoration zone) (*Figure 1; Table 1*).

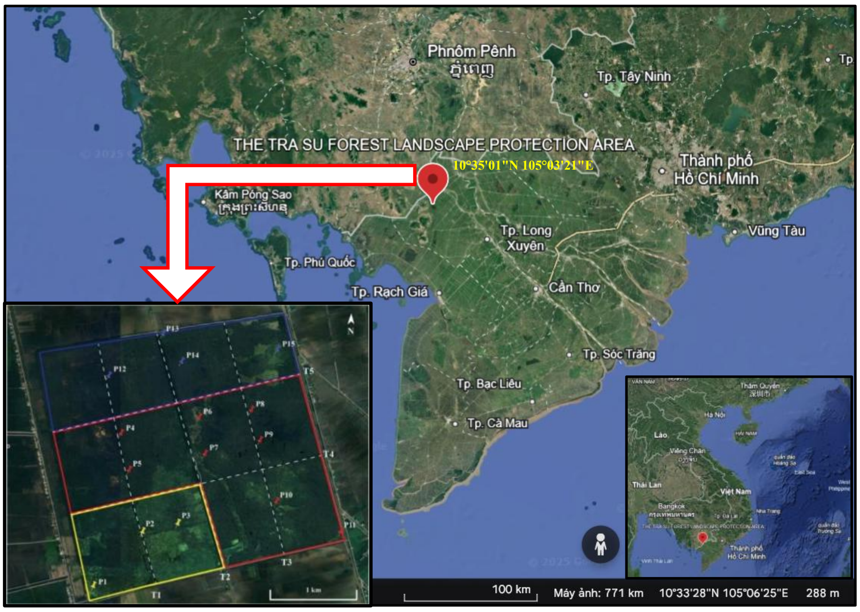

***Figure 1.** Sampling map at Tra Su Melaleuca Forest (P1-P15: 15 sampling sites)*

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Table 1. *Sampling sites at Tra Su Melaleuca Forest*

S	Coordinates	S	Coordinates
Area I: Administrative Area (yellow zone)		**8**	10°35’21.7"N 105°03’52.3"E
1	10°34’12.8"N 105°02’56.1"E	**9**	10°35’09.3"N 105°03’55.4"E
2	10°34’26.7"N 105°03’14.5"E	**10**	10°34’37.7"N 105°04’02.9"E
3	10°34’19.0"N 105°03’20.1"E	**11**	10°34’35.2"N 105°04’27.8"E
Area II: Strict Protection Area (red zone)		*Area III: Ecological Restoration Area (blue zone)*	
4	10°35’10.6"N 105°03’04.7"E	**12**	10°35’43.5"N 105°02’57.5"E
5	10°34’54.9"N 105°03’08.0"E	**13**	10°35’50.8"N 105°03’18.4"E
6	10°35’22.7"N 105°03’28.0"E	**14**	10°35’43.0"N 105°03’21.4"E
7	10°35’03.1"N 105°03’33.2"E	**15**	10°35’41.6"N 105°04’10.0"E

*S: Sampling site

Sample collection and analysis

Benthic macroinvertebrates were collected using a Petersen grab (0.03 m^2 per grab) with five replicates per site. Sediment samples were washed through a 0.5 mm mesh sieve to remove excess mud and retain macrofauna. The retained material was fixed in 4% buffered formalin and transported to the laboratory for further analysis.

The samples were carefully selected, with all organic matter removed, and benthic macroinvertebrates were chosen according to the definition of Tagliapietra and Sigovini (2010) and then fixed in a 4% formalin solution for analysis.

Qualitative analysis

The morphological characteristics and structure of the benthic macroinvertebrate genera and species collected were observed with the naked eye, magnifying glass, or Motic microscope (DM143 SERIES) at appropriate magnification. Species identification was based on published taxonomic references by Usinger et al. (1971), Dang et al. (2002), Vu (2009), and Vu and Duong (2013).

Quantitative analysis

The number and biomass of benthic macroinvertebrates were determined for each group within each sample. Benthic macroinvertebrates density (D, individuals/m^2) was calculated using the formula:

$$D = \frac{X}{S} \quad \text{(Eq.1)}$$

where X is the number of individuals of each benthic group in the collected sample, and S is the sampling area, calculated as S = n×d (m^2), with n being the number of grabs and d the area of each grab.

Biodiversity indices

Variations in species composition and the number of planktonic animals in the ecosystem were analyzed through diversity indices such as the Margalef index (d), Pielou’s evenness index (J’), the Shannon-Wiener diversity index (H’), and Simpson’s Diversity Index (1 – λ’).

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+ *Margalef's species richness index (d)* (Margalef, 1958):

$$d = \frac{S-1}{\ln(N)} \quad \text{(Eq.2)}$$

where S is the total number of species, and N is the total number of individuals.

+ *Pielou's evenness index (J')* (Pielou, 1966):

$$J' = \frac{H'}{\ln(S)} \quad \text{(Eq.3)}$$

where S is the total number of species and H' is the Shannon-Wiener diversity index.

+ *Shannon-Wiener diversity index (H')* (Shannon, 1948):

$$H' = -\sum(pi \times \ln(pi))\,;\, pi = \frac{ni}{N} \quad \text{(Eq.4)}$$

where ni is the number of individuals of species *i*, and N is the total number of individuals.

+ *Simpson's Diversity Index (1 – λ')* (Simpson, 1949): index measures the probability that two individuals randomly selected from a sample will belong to the same species,

$$\lambda' = -\sum_{i=1}^{S} \frac{ni \times (ni-1)}{N \times (N-1)} \quad \text{(Eq.5)}$$

where: ni: number of individuals of species I, N: total number of individuals of all species, and S: total number of species.

Statistical analysis

ANOVA with Tukey's post-hoc test was used to evaluate spatial and seasonal (wet and dry) differences in biodiversity indices, including species richness (S), total abundance (N), Margalef's index (d), Pielou's evenness (J'), Shannon–Wiener diversity index (H'), and Simpson's index (1–λ'), at a significance level of 5%.

Results and discussion

Species composition and distribution

A total of 408 individuals representing 20 benthic macroinvertebrate species were recorded in the Tra Su Melaleuca Forest, with 297 individuals collected in the dry season and 111 in the wet season. These species were classified into three phyla and four classes, with the phylum *Mollusca* contributing the highest species richness. In particular, *Mollusca* accounted for 16 species (80% of the total), including 7 species of *Bivalvia* and 9 species of *Gastropoda*. In contrast, *Annelida* and *Arthropoda* were underrepresented, comprising only one and three species, respectively (*Table 2, Fig. 2*).

The most abundant species included *Marisa* sp. (59 individuals), *Melanoides tuberculata* (46), and *Clea helena* (46), all of which are tolerant of eutrophic and organically enriched environments. In contrast, the low abundance of *Oligochaeta* (*Limnodrilus hoffmeisteri*) and several crustaceans may reflect localized environmental

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stressors. The dominance of mollusks, particularly gastropods and bivalves, underscores the ecological suitability of this wetland for taxa adapted to stagnant or slow-flowing waters with high organic content. This distribution pattern supports previous studies highlighting the role of mollusks as sensitive bioindicators of aquatic ecosystem health (Dillon, 2000; Benchamin et al., 2024). Their filter-feeding capacity, especially among bivalves, contributes to nutrient cycling and organic matter decomposition (Holovkov et al., 2023; Künili, 2024), thereby linking their abundance to water quality. Furthermore, analyzing mollusk diversity and population structure offers insights into trophic dynamics and habitat conditions within freshwater ecosystems (Covich et al., 1999).

Table 2. *Species composition structure of benthic macroinvertebrates in the Tra Su Melaleuca Forest*

No.	Species	Number of species	Frequency of occurrence	Number of individuals (NI)*		
				Dry	Wet	All
Mollusca						
I.1. Bivalvia						
1.	*Mycetopoda siliquosa*	7	35.00%	4	5	9
2.	*Corbicula leana*			5	15	20
3.	*Corbicula subsulcata*			2	3	5
4.	*Corbicula tenuis*			14	19	33
5.	*Corbicula sp.*			1	14	15
6.	*Lutraria philippinarum*			0	6	6
7.	*Sinanodonta jourdyi*			0	2	2
I.2. Gastropoda						
8.	*Sinotaia quadrata*	9	45.00%	18	2	20
9.	*Bellamya aeruginosa*			20	1	21
10.	*Clea helena*			30	16	46
11.	*Melanoides tuberculata*			38	8	46
12.	*Pomacea canaliculata*			37	3	40
13.	*Pomacea lineata*			13	2	15
14.	*Pila polita*			2	2	4
15.	*Marisa sp.*			55	4	59
16.	*Physella acuta*			27	0	27
Arthropoda						
II.1. Malacostraca						
17.	*Macrobrachium lanchesterri*	3	15.00%	10	6	16
18.	*Palaemon varians*			3	0	3
19.	*Esanthelphusa dugasti*			18	0	18
Annelide						
III.1. Oligochaeta						
20.	*Limnodrilus hoffmeisteri*	1	5.00%	0	3	3
Total		**20**	**100.00%**	**297**	**111**	**408**

*The values represent the total number of individuals recorded for each species during the dry and rainy seasons and the overall total

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Figure 2. *Benthic macroinvertebrates recorded in the Tra Su Melaleuca Forest (A-D: Gastropoda, Bivalvia, Malacostraca, and Oligochaeta, respectively; A1: Clea helena; A2: Pomacea canaliculata; A3: Pomacea lineata; A4: Melanoides tuberculata; A5: Pila polita; A6: Marisa sp.; A7: Sinotaia quadrata; A8: Bellamya aeruginosa; A9: Physella acuta; B1: Mycetopoda siliquosa; B2: Corbicula leana; B3: Corbicula subsulcata; B4: Corbicula tenuis; B5: Corbicula sp.; B6: Lutraria philippinarum; B7: Sinanodonta jourdyi; C1: Palaemon varians; C2: Macrobrachium lanchesterri; C3: Esanthelphusa dugasti; D1: Limnodrilus hoffmeisteri)*

Monitoring changes in benthic communities is essential for assessing ecological trends in wetland environments. Compared with earlier surveys, the current study recorded a slightly higher species richness than that reported by Le et al. (2019), who found 15 species in the same area. This increase may result from temporal ecological variation, enhanced sampling resolution, or shifts in environmental conditions. Notably, 14 species were newly recorded, contributing to the expansion of the regional benthic fauna inventory. While seven species overlapped with previous findings, four were not detected again. These shifts may be influenced by environmental stressors, such as acid sulfate soils and thick layers of *Melaleuca* leaf litter (>50 cm), which likely reduce oxygen penetration and limit the detectability of small or burrowing taxa. Such factors should be considered when interpreting biodiversity patterns in forested wetland ecosystems.

Spatial and seasonal distribution

Figure 3 illustrates the species composition at each sampling site across both seasons. Area III consistently supported the highest species richness, particularly at Site 13, which recorded nine species in the wet and seven in the dry seasons. This site benefits from regular hydrological exchange with adjacent water bodies, promoting stable physicochemical conditions and nutrient input (Yang and Yang, 2019; Allan et al., 2021; Feng et al., 2025). In contrast, no species were recorded at Site 4 in either season, likely due to poor water circulation and unsuitable sediment composition.

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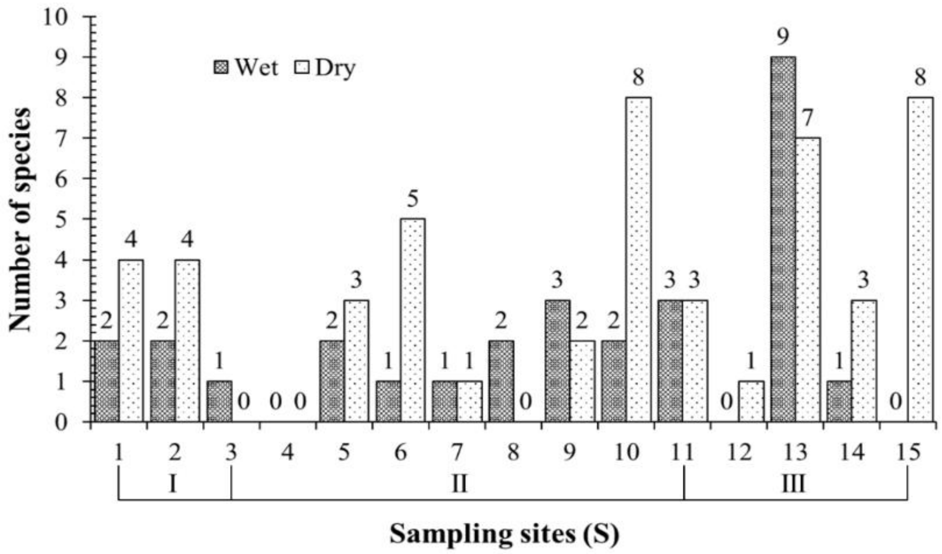

Figure 3. *Distribution of species composition at sampling sites (I-III respectively: Area I, II, and III) in Tra Su Melaleuca Forest*

The density of benthic macroinvertebrates (NI/m²)

According to *equation (1)*, benthic macroinvertebrate species were categorized into two functional groups based on their mobility and substrate preferences: (1) BO group (Bivalvia and Oligochaeta): slow-moving and burrowing species, primarily associated with fine mud; and (2) GM group (Gastropoda and Malacostraca): more mobile species with broader habitat tolerance.

The BO group exhibited higher densities during the wet season, likely due to increased deposition of suspended organic matter and fine sediment, which offer both food and microhabitat. For instance, *Lutraria philippinarum*, *Sinanodonta jourdyi*, and *Limnodrilus hoffmeisteri* were recorded exclusively during the wet season. Average densities for BO species ranged from 20 to 127 individuals/m² in the wet season, compared to 7 to 93 individuals/m² in the dry season. Conversely, GM species were more abundant during the dry season, likely benefiting from more stable hydrological conditions and concentrated food resources. *Marisa* sp. exhibited the highest observed density (367 individuals/m²) in the dry season. Densities of other GM species ranged from 13 to 253 individuals/m² in the dry season and 7 to 127 individuals/m² in the wet season. Increased flow velocity and turbidity during the wet season may reduce habitat stability and sampling detectability for this group (*Fig. 4*).

These seasonal density patterns reflect adaptations to environmental heterogeneity, consistent with findings from other tropical floodplain wetlands (Vause et al., 2019; Gammal et al., 2025). For example, Ge et al. (2025) emphasized that seasonal transitions between wet and dry periods strongly influence benthic community structure via temperature shifts, flow regime changes, and nutrient availability.

When compared with the findings of Le et al. (2019), *Corbicula tenuis* increased from 24 individuals/m² to 127 individuals/m²—representing a 5.3-fold increase. In contrast, *Limnodrilus hoffmeisteri* slightly declined from 31 to 20 individuals/m². These trends may indicate improved habitat conditions for filter feeders while suggesting localized stressors for sediment-dwelling oligochaetes.

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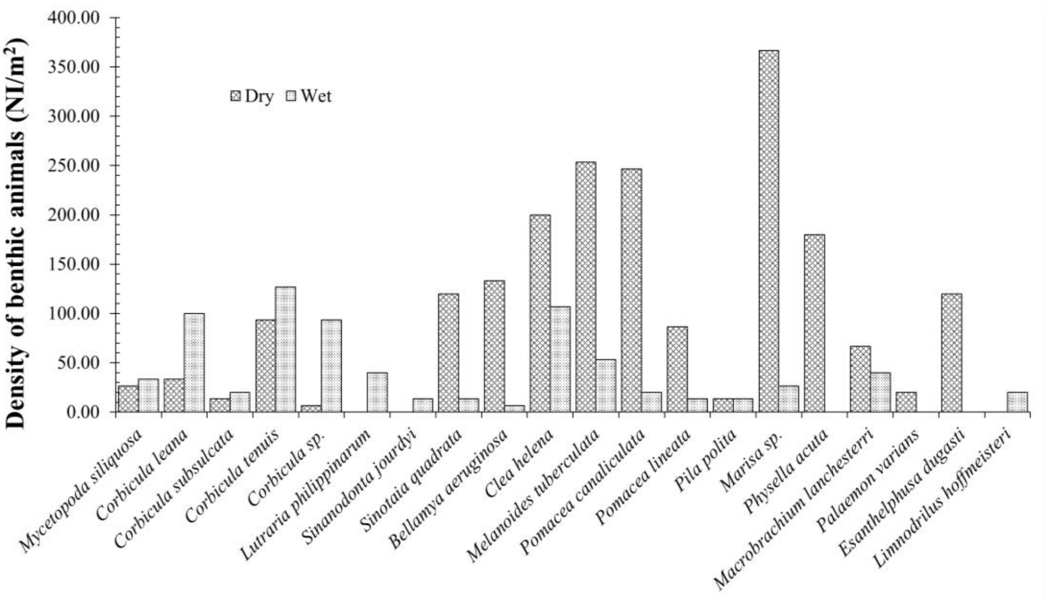

Figure 4. *Individual density (individuals/m²) of benthic macroinvertebrate species in Tra Su Melaleuca Forest*

Frequency of occurrence (%)

Despite an overall increase in species richness, frequency of occurrence remained relatively low across sites, indicating spatially clustered distributions and low dispersal among benthic macroinvertebrates. As shown in *Figure 5*, eight of the twenty recorded species were found at only a single site, either seasonally or year-round.

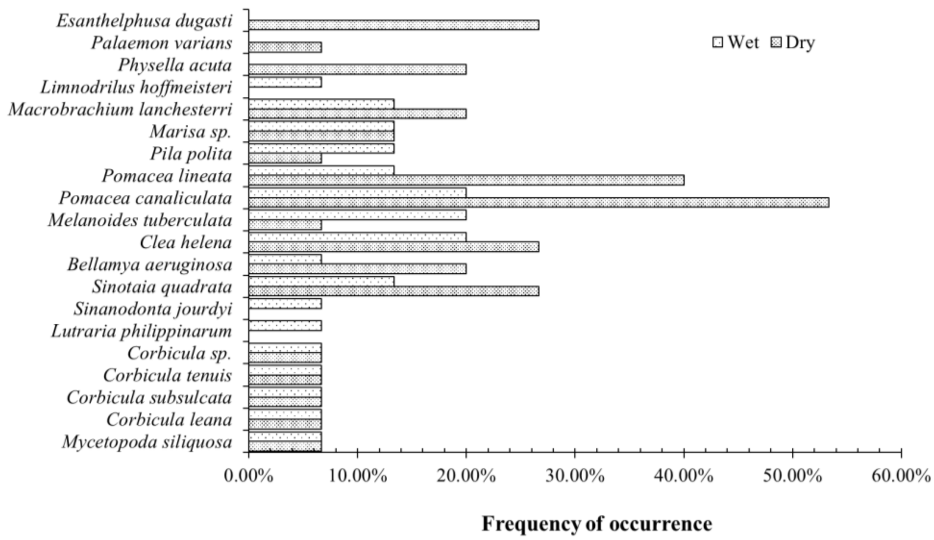

Figure 5. *Frequency of occurrence of species recorded in the Tra Su Melaleuca Forest*

As with density, species frequency was analyzed by functional group. The BO group was limited to a single site (Site 13), likely due to its restricted mobility and dependence on stable, fine-sediment habitats. In contrast, GM species exhibited broader habitat

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utilization, though most were still recorded at relatively few sites. The only exception was *Pomacea canaliculata*, which appeared at 9 of 15 sites (~60%). The fragmented hydrological landscape of Tra Su Melaleuca Forest, characterized by compartmentalized wetland units with limited interconnectivity, may inhibit the dispersal and recolonization of benthic fauna. The case of *Pomacea canaliculata* was particularly noteworthy: as an invasive alien species, it showed both high frequency and density (247 individuals/m²) during the dry season. Its proliferation poses significant ecological risks, including damage to aquatic vegetation, competition with native fauna, and community destabilization (Truong et al., 2023; Pham and Nguyen, 2024). Targeted monitoring and management strategies are thus essential to control its spread within the study area.

Benthic biodiversity indices across different areas in Tra Su Melaleuca Forest

The analysis of biodiversity indices revealed distinct spatial patterns across the three study areas, according to *equations (2) to (5)*. Area III exhibited the highest biodiversity values, while Area I consistently showed the lowest. However, this difference is not statistically significant ($p > 0.05$), with the p-values for the biodiversity indices d, J′, H′, and 1-λ′ being 0.64, 0.45, 0.95, and 0.54, respectively. Regarding species richness (S), Area III supported 12 species in the dry season and 10 in the wet season—outperforming Area I, which harbored only 3–4 species per season. However, seasonal differences in species richness across areas were not statistically significant ($p > 0.05$). Concerning abundance, Area III contributed the largest share, accounting for 166 individuals (40.69% of total specimens). This numerical dominance was reflected in its biodiversity indices, including a Shannon–Wiener diversity index (H′) of 0.92 and a Simpson's dominance complement (1 – λ′) approaching unity—indicating high diversity and evenness. In contrast, Area I exhibited lower values across all metrics, particularly H′ (as low as 0.24 in the dry season) and J′ (as low as 0.40), suggesting both low richness and skewed community composition (*Table 3*).

Table 3. *Biodiversity indices and statistical test results across study areas in the Tra Su Melaleuca Forest*

Area	S		N		d		J’		H’		1 – λ’	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
I	4	3	64	7	0.72	1.03	0.40	0.87	0.24	0.42	0.28	0.67
II	9	9	105	22	1.72	2.59	0.84	0.92	0.80	0.88	0.81	0.89
III	12	10	83	83	2.49	2.04	0.85	0.88	0.92	0.88	0.87	0.86
Results of statistical analysis												
F	0.88		16.59		0.34		1.46		0.53		0.38	
df	2.00		2.00		2.00		2.00		2.00		2.00	
p	0.54		0.06		0.75		0.45		0.67		0.74	

*S: Species richness; N: Number of individuals, d: Margalef's richness index; J′: Pielou's evenness index; H′: Shannon–Wiener diversity index; 1 – λ′: Simpson's diversity index. F: F-statistic from ANOVA; df: degrees of freedom; p: probability value

Despite apparent numerical fluctuations between seasons, statistical analyses confirmed that seasonal changes were not significant across diversity indices ($p > 0.05$). This suggests that benthic community structure is relatively stable seasonally and may

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be shaped more strongly by spatial environmental heterogeneity than temporal variability (Dube et al., 2017; Mushet et al., 2019). These spatial biodiversity gradients likely reflect differences in ecological quality and hydrological stability among areas. Area III, which experiences consistent water exchange and reduced habitat disturbance, provides favorable environmental conditions for diverse benthic communities. In contrast, Area I appears to suffer from hydrological fragmentation, limited organic inputs, and habitat simplification—factors previously linked to biodiversity loss in floodplain ecosystems (Xuan et al., 2022). Although Tra Su Melaleuca Forest's benthic communities displayed some resilience to seasonal hydrological cycling—evidenced by stable H′ and 1 – λ′ values—local environmental stressors likely constrain richness and evenness in more isolated or disturbed zones. This resilience aligns with findings from other subtropical wetlands, where pulse flow regimes maintain benthic stability despite fluctuations in hydrology and abundance.

Conclusion

This study revealed marked spatial variation in benthic macroinvertebrate diversity within the Tra Su Melaleuca Forest, with Area III consistently supporting higher species richness and diversity, while Area I remained biologically impoverished. These differences reflect the critical role of local habitat conditions and hydrological connectivity in shaping benthic community structure. Despite observed seasonal changes in abundance, biodiversity indices remained relatively stable, indicating ecological resilience to hydrological fluctuations. These findings underscore the importance of conserving structurally diverse and well-connected wetland areas to maintain benthic biodiversity. Habitat restoration and improved hydrological management in degraded zones—especially those with limited water exchange—may enhance ecological function and support long-term biodiversity conservation. Using standardized diversity metrics in routine monitoring is also recommended to inform adaptive wetland management strategies in the Mekong Delta.

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REFERENCES

[1] Allan, J. D., Castillo, M. M., Capps, K. A. (2021): Stream ecology: structure and function of running waters. – Springer Nature.
[2] Benchamin, D., Sreejai, R., Arya, M. (2024): Spatial and temporal variation in diversity and abundance of Malacostraca associated with environmental variables in a tropical River in South India. – Aquatic Ecology: 58: 1013-1031.
[3] Covich, A. P., Palmer, M. A., Crowl, T. A. (1999): The role of benthic invertebrate species in freshwater ecosystems: zoobenthic species influence energy flows and nutrient cycling. – BioScience 49: 119-127.

[4] Dang, N. T., Ho, T. H., Duong, D. T., Mai, D. Y. (2002): Freshwater Aquatic Biology of Inland Water Bodies in Vietnam: Ha Noi. – Science and Technology Publisher.
[5] Dillon, R. T. (2000): The ecology of freshwater molluscs. – Cambridge University Press.
[6] Dube, T., DeNecker, L., Van Vuren, J. H., Wepener, V., Smit, N. J., Brendonck, L. (2017): Spatial and temporal variation of invertebrate community structure in flood-controlled tropical floodplain wetlands. – Journal of Freshwater Ecology 32(1): 1-15.
[7] Feng, Y., Yang, M., Chen, H., Tang, F., Liu, X., Shi, J., Yang, H. (2025): Research on the seasonal driving mechanisms of benthic macroinvertebrate communities in streams. – Frontiers in Ecology and Evolution 13: 1536181.
[8] Gammal, J., Järnström, M., Norkko, J., Bonsdorff, E., Norkko, A. (2025): Seasonal Variation in the Role of Benthic Macrofauna Communities for Ecosystem Functioning in Shallow Coastal Soft-Sediment Habitats. – Estuaries and Coasts 48: 62.
[9] Ge, J., Chen, J., Zi, F., Song, T., Hu, L., He, Z., Wu, L., Ding, Y., Li, H. (2025): Seasonal Variations in Macrobenthos Communities and Their Relationship with Environmental Factors in the Alpine Yuqu River. – Biology 14: 120.
[10] Holovkov, A., Kovalenko, V., Sova, A. (2023): Application of bivalve molluscs in the biological purification of polluted natural waters. – Journal of Water Chemistry and Technology 45: 481-486.
[11] Jana, B. (2024): Aquatic Sciences in the Tropics: Plankton, Animal Community and Productivity. – CRC Press.
[12] Künili, İ. E. (2024): Comparative analysis of the efficiency of different commercial depuration systems and the evaluation of species-specific depuration conditions in bivalve mollusc production. – Aquacultural Engineering 107: 102468.
[13] Le, V. D., Tran, P. H., Le, T. T., Nguyen, V. C. N. (2019): Applying the BMWPVIET-ASPT biological index to survey surface water quality at Tra Su forest - An Giang province. – Can Tho University Journal of Science 55: 261-269.
[14] Margalef, R. (1958): Information theory in ecology. – General Systems: Yearbook of the International Society for the Systems Sciences 3: 1-36.
[15] Mushet, D. M., Solensky, M. J., Erickson, S. F. (2019): Temporal gamma-diversity meets spatial alpha-diversity in dynamically varying ecosystems. – Biodiversity and Conservation 28(7): 1783-1797.
[16] Pham, C. T., Nguyen, H. T. T. (2024): Study on diversity index, evenness index, and species composition of snails in irrigation canals for rice fields in Duc Hue district, Long An province. – Hung Vuong University Journal of Science and Technology 35: 65-73.
[17] Pielou, E. C. (1966): The measurement of diversity in different types of biological collections. – Journal of Theoretical Biology 13: 131-144.
[18] Shannon, C. E. (1948): A mathematical theory of communication. – The Bell System Technical Journal 27: 379-423.
[19] Simpson, E. H. (1949): Measurement of diversity. – Nature 163: 688-688.
[20] Tagliapietra, D., Sigovini, M. (2010): Benthic fauna: collection and identification of macrobenthic invertebrates. – Terre et Environnement 88: 253-261.
[21] Truong, H. D., Le, T. T. L., Ly, V. L., Le, T. D. M. (2023): Assessment of invasiveness of invasive alien species in An Giang province. – Journal of Environmental Science and Resources 47: 161-175.
[22] Usinger, R. L., Bentinck, W., Chandler, H., Day, W., Denning, D., Hagen, K., Jewett, S., Lange, W., Rivers, L., Lattin, J. (1971): Aquatic insects of California-With keys to North American genera and California species. – University of California Press.
[23] Vause, B. J., Morley, S. A., Fonseca, V. G., Jażdżewska, A., Ashton, G. V., Barnes, D. K., Giebner, H., Clark, M. S., Peck, L. S. (2019): Spatial and temporal dynamics of Antarctic shallow soft-bottom benthic communities: ecological drivers under climate change. – BMC Ecology 19: 1-14.
[24] Vietnam Association for Conservation of Nature and Environment (2011): Tra Su Melaleuca Forest in An Giang has rich ecotourism potential and serves as a successful

model for the sustainable use of biodiversity in the Mekong Delta. – [Online]. Available: https://vacne.org.vn/rung-tram-tra-su-an-giang-cid35737.html [Accessed: May 2025].

[25] Vu, T. T. (2009): Ecology of Estuarine Systems in Vietnam. – Education Publisher.

[26] Vu, N. U., Duong, T. H. O. (2013): Textbook of Aquatic Plants and Animals. – Can Tho University Publishing House (in Vietnamese).

[27] Xuan, N. V., Giang, N. N. L., Ty, T. V., Kumar, P., Downes, N. K., Nam, N. D. G., Ngan, N. V. C., Thinh, L. V., Duy, D. V., Avtar, R., Thu Minh, H. V. (2022): Impacts of dike systems on hydrological regime in Vietnamese Mekong Delta. – Water Supply 22: 7945-7959.

[28] Yang, R., Yang, D. (2019): Traditional Settlements Study on Sciences of Human Settlements in Erhai Lake Region. – IOP Conference Series: Materials Science and Engineering, 2019. IOP Publishing.

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