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RELATIONSHIP OF FREE-LIVING NEMATODE COMMUNITIES TO SOME ENVIRONMENTAL VARIABLES IN AN ORGANIC SHRIMP FARMS, CA MAU PROVINCE

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Abstract. Free-living nematode communities (FLNC) in the Tam Giang's organic shrimp farms ponds (TGOSFP), Nam Can district, Ca Mau province were investigated in three seasons (March - dry, July - transfer (trans) and November - wet season) of 2015. Our findings underlined that the FLNC were expressed by high density and diversity. The environmental condition in the TGOSFP was characterized by a high percentage of TN, TOC, low pH, and anaerobic condition in sediment that was not optimal conditions for shrimp farming. The results of CCA analysis showed that main environmental parameters such as TN, TOC, depth, DO, salinity, and pH almost completely governed the abundances of dominant genera such as *Desmodora, Sabatieria, Terschellingia, Dichromadora, Pomponema, Halalaimus, Ptycholaimellus,* and *Sphaerotheristus*. Subsequently, the results of Pearson correlation confirmed that the abundances of genus *Sabatieria*, *Terschellingia* were significantly positively correlated with TOC, TN, and depth. In contrast, *Desmodora*, *Halalaimus*, and *Ptycholaimellus* were negative correlations with organic enrichment (TOC and TN). However, most genera were positively correlated with salinity. The combination of dominant nematode genera and maturity index (MI) value indicated that the ecological quality status of sediment (EcoQ) in TGOSFP was moderate to poor EcoQ. The attribute of FLNC and their correspondence with environmental characteristics can be considered as a good tool for environmental monitoring.

Keywords: ecological quality status of sediment, environmental monitoring, indicator, nematode communities, organic shrimp farms ponds.

Classification numbers: 3.1.2; 3.4.2

1. INTRODUCTION

Viet Nam is a country with a long coastline (approximately 3,260 kilometers). It has the potential to support a mangrove ecosystem. The mangrove forests in Viet Nam is divided into 4 main zones according to Phan & Hoang [1]: Zone 1 (from Ngoc cape to Do Son cape - Northeast coast), Zone 2 (from Do Son cape to Lach Truong river - Northern delta), Zone 3 (from Lach Truong to Vung Tau cape - Central coast) and Zone 4 (from Vung Tau cape to Ha Tien - Southern delta). Many studies have demonstrated the importance of mangrove forests in natural processes and the socio-economic lives of Viet Nam's coastal inhabitant. Mangroves not only provide organic matter to the marine environment, exporting nutrients for living organisms in both the mangrove forest, surrounding estuarine and marine ecosystems [2], but also supply many commercially important aquatic and terrestrial fauna with food, habitat, nurseries and breeding places [3]. Mangroves forests have been traditionally exploited as firewood, building materials, honey, medicinal plants, and other raw products for local consumption [4, 5]. Taken together, they could contribute significantly to stabilize coastlines, promote coastal accretion, in many cases provide a natural barrier against hurricanes, tsunamis, cyclones, and other potentially damaging natural forces [4, 5]. And they also attract eco-ecotourists, fishers, hunters, hikers, and birdwatchers, to provide a potential source of income for local dwellers [3]. Mangrove forests are declining worldwide.

Due to the use of herbicides during the American war, and conversion of mangroves for aquaculture and agriculture, specifically for shrimp farms, the area mangrove forests in Viet Nam have declined considerably from 400,000 ha in the 1960s to 155,290 ha in 2005 [6]. National strategic planning has attempted to reduce these impacts through the development and widespread dissemination of the model organic shrimp farms. This model is distinguished from other shrimp grow-out the system by avoiding using synthetic products, all input materials shall be natural products. In spite of the wide area of this model, to date, studies in organic shrimp farm ponds have not been adequately investigated. Until recently referred only to the physicochemical characteristics [7, 8], plankton [9], and meio-macrofaunal [8, 10, 11] in organic shrimp farm ponds. Free-living nematode communities are one major component of many marines and freshwater benthic habitats. They are food resource for larger benthic invertebrates and vertebrates (e.g. amphipod, insect larvae, mysid, grass shrimp, fish, etc.), thus playing an important role in the benthic food web [12]. Some information discussed above, we are also confident that free-living nematode communities (FLNC) plays important roles in marine and freshwater benthic ecosystems in general and organic shrimp farms in particular**.**

The purposes of this work are to (i) identify free-living nematode communities and the environmental variables in an organic shrimp farms ponds, (ii) determine the correlation between dominant nematode genera with main environmental variables and (iii) detect the EcoQ in Tam Giang's organic shrimp farms ponds (TGOSFP) through dominant nematode genera and MI value.

2. MATERIALS AND METHODS

2.1. Sampling location

Ca Mau province located in the Mekong Delta, South Viet Nam has been recorded as the largest area of mangrove forests but it has come to be known as the greatest shrimp production and farming area of the country [13]. The largest area of organic shrimp farms in Ca Mau province has largely concentrated in Dam Doi, Cai Nuoc and Nam Can districts. Besides the big river of Cua Lon with a large area of mangrove forests, Tam Giang commune (a rural commune of Nam Can district, forms a roughly 95.31 km^2) created favorable conditions for the development and widespread dissemination of the model organic shrimp farms.

Triplicate sediment samples for FLNC and environmental variables analyses were collected together at 8 organic shrimp farms ponds in the Tam Giang commune (coded P1, P2, P3, P4, P5, P6, P7, and P8) (Fig. 1).

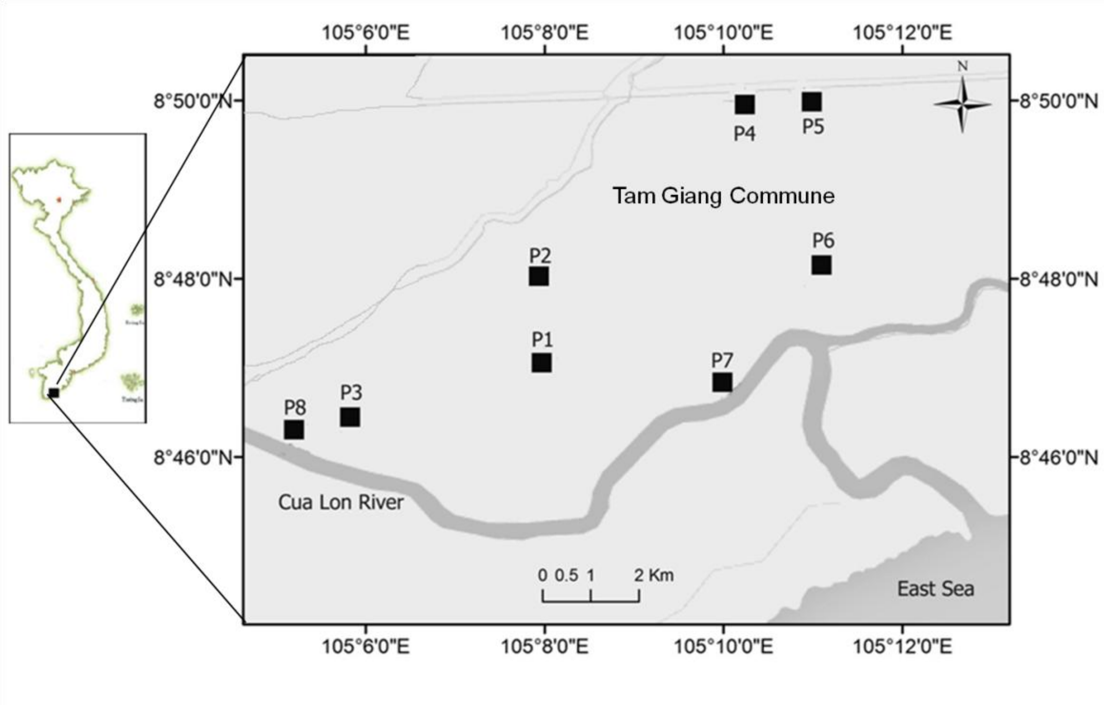

Figure 1. Map of sampling stations in Tam Giang's organic shrimp farms ponds.

2.2. Nematodes sampling

At each pond, triplicate nematode samples were collected using a core of 3.5 cm in diameter (10 cm^2 surface area) and 30 cm in length. The cores were pushed down into the soft-bottom up to 10 cm deep. The samples were all fixed in a 7 % formaldehyde solution at 60 °C and gently stirred. Nematodes were sieved from the sediment by sieving through a 1 mm mesh and keeping the fraction retained on a 38 μm mesh. Subsequently, nematodes were extracted by the flotation technique with Ludox - TM50 (specific gravity 1.18) [14]. In order to facilitate sorting of nematodes, the samples were stained with 3 – 5 ml solution of Rose Bengal 1 %. About 100 nematode specimens were picked out randomly per sample and processed for making permanent slides according to the method of De-Grisse (1969) [15]. Nematodes were identified to genus level by using the identification keys of Warwick et al. [16], Zullini [17], Nguyen [18] and Vanaverbeke et al. [19].

2.3. The environmental characteristics

The overlying water samples were collected at a depth of 20 cm. Different environmental variables including pH of sediment, dissolved oxygen (DO), salinity and pond depth were measured *in situ* using a multi-parameter (WQC - 22A, Co, TOA - DKK). Sediment samples were collected using a Ponar grab and kept in glass bottles and transported to the laboratory for the physicochemical analyses. Analysis processes of sediment samples of total nitrogen (TN), total organic carbon (TOC), Fe^{2+} and Fe^{3+} have been described in detail in Tran et al. [8].

2.4. Data analyses

The environmental data were normalized and a Principal components analysis (PCA) was performed to identify the multivariate ordination of the main environmental variable in three seasons. All of these processes were performed in the software PRIMER VI.

Free-living nematode communities data were analyzed using PRIMER VI software for (i) calculating a univariate index (Shannon index (H’)), (ii) identifying the average abundances of dominant genera and their contribution in TGOSFP by using the SIMPER analysis (SIMilarity PERcentages). Addition, the MI value was calculated based on life history characteristics according to the method of Bongers [20]. Two - way ANOVA test was carried out to compare the environmental variables and the FLNC structure metrics between seasons and between ponds. All statistical analysis was performed using the software STATISTICA 7.0.

Canonical correspondence analysis (CCA) was performed to identify the multivariate ordination of the main environmental variables driving force that governs nematode dominant genera. All variables were log - transformed to normalize their distributions before analysis. Monte Carlo permutation tests were used to reduce further the environmental variables to those correlated significantly with the derived axes. CCA and ordination plot were performed using the software CANOCO version 4.5 for Windows. Subsequently, in order to investigate the significant correlation between environmental data with nematode dominant genera, the software STATISTICA 7.0 was used to calculate the Pearson correlation analysis (r coefficients).

3. RESULTS AND DISCUSSION

3.1. Characteristics of free-living nematode communities in the Tam Giang’s organic shrimp farms ponds

Overall, the nematode assemblages in the TGOSFP did not fluctuate greatly between dry and trans seasons. More specifically, in dry FLNC consisted of 75 genera belonging to 24 families, 7 orders; 71 genera belonging to 26 families, 10 orders in trans. However, FLNC in wet season was a relatively low number of genera (57 genera, 26 families, and 9 orders). During the study period, the most individuals belong to seven dominant orders such as Araeolaimida, Chromadorida, Desmodorida, Monhysterida, Plectida, Enoplida, and Mononchida. Trans season added three orders (Desmoscolecida, Dorylaimida, and Triplonchida) to their composition. Addition, a number of orders in wet season were similar to those in trans (except for order Dorylaimida).

The average density (inds/10 cm^2) ranged from 221 ± 122 to 2539 ± 1403 in dry, 1020 ± 354 to 7254 ± 5454 in trans and from 822 ± 1086 to 4608 ± 1302 in wet seasons (Fig. 2A). The diversity of FLNC was measured by the Shannon - Wiener (H’ ($\log_2$)). The H’ ranged from 2.35 ± 1.02 to 3.61 ± 0.24 in dry, ranging between 2.79 ± 0.57 - 3.51 ± 0.20 for trans and between 2.14 ± 1.07 - 3.51 ± 0.17 for wet season (Fig. 2B). Regarding MI value, it ranged from 2.20 ± 0.24 to 2.64 ± 0.19 in the dry season. The trans and wet season also showed a lower value, from 2.26 ± 0.13 to 2.60 ± 0.08, 2.09 ± 0.11, 2.58 ± 0.12, respectively (Fig. 2C).

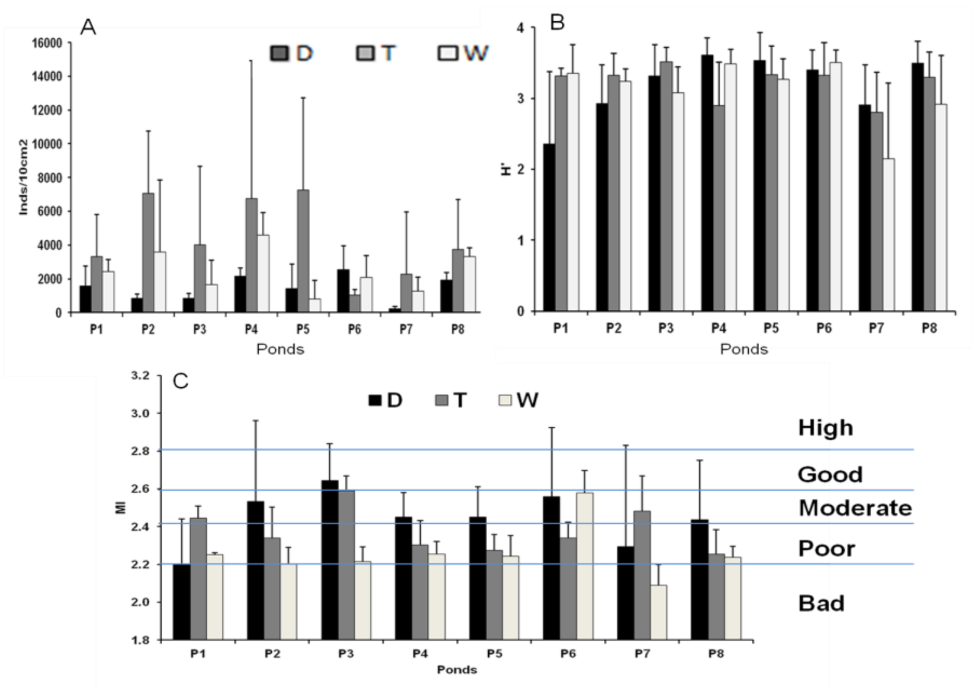

Figure 2. Characteristics of free-living nematode communities in Tam Giang's organic shrimp farms ponds for densities (A), H'(B) and MI value (C).

A two - way ANOVA test was carried out to compare the density, H' and MI value between seasons and between ponds. Results indicated that one factor (seasons) had a statistically significant effect on densities and MI value. In addition, the ponds factor had a statistically significant effect on H' value (Table 1).

Table 1. The results of a two - way ANOVA for the environmental characteristics and the free-living nematode communities structure metrics (p - values < 0.05 indicated with bold values).

p-value	Environmental and the free-living nematode community characteristics									
	DO	Salinity	pH	Fe^{2+}	Fe^{3+}	TOC	TN	Density	H'	MI
p - seasons	0.59	< **0.01**	< **0.01**	0.08	< **0.01**	0.09	**0.02**	< **0.01**	0.76	**0.01**
p - ponds	< **0.01**	< **0.01**	< **0.01**	0.26	0.27	< **0.01**	< **0.01**	0.29	**0.02**	0.22
p - seasons*ponds	0.25	< **0.01**	**0.02**	0.19	0.10	0.06	0.17	0.65	0.15	0.29

The high abundances and diversity of FLNC in TGOSFP is a rich food source for the diet of shrimp. Presently, the black tiger shrimp (*Penaeus monodon*) has widely farmed in the Mekong Delta [7]. El Hag [21] has warned that the *Penaeus monodon* adults have come to be known as the omnivorous, from organic detritus to small organisms, such as fish, crustacea, mollusks, and Polychaeta. However, the favorite food of shrimp is nematodes and small organism than for any others [22]. This is evidence that FLNC is playing important role in the benthic food web, particularly in the diet of shrimp.

The results of this study indicated that the FLNC in the TGOSFP has characterized by high abundances and diversity. The density of FLNC in the TGOSFP was higher than observed in several studies such in Can Gio mangrove mudflat (1,156 - 2,032 inds/10cm^2) [23], Bengal mangrove, India (35 - 280 inds/10 cm^2) [24], South Cuba mangrove (36 - 245 inds/10 cm^2) [25] and in Hinchinbrook Island, Australia (14 – 1,840 inds/10 cm^2) [26]. Furthermore, the abundances of FLNC in the TGOSFP were similar to the more recently observed in Gazi Bay, Kenya (1,976 - 6,707 inds/10cm^2) [27].

Addition, the FLNC in the TGOSFP also characterized by high diversity. The H’ index was higher than the H’ value reported in the Victoria, SE Australia, with about 0.558 ± 0.084 [28], in Merbok, Malaysia with H’ amounted from 2.0 to 3.2 [29] and in the Cape York Peninsula, Australia (2.02 - 2.91) [26], but lower than in the Can Gio mangrove mudflat, with H’ from 3.6 to 4.2 [23]. And was not much different from Marennes - Oléron, France (2.7 - 3.5) [30] and in Santa Catarina, South Brazil (2.5 - 3.5) [31].

3.2. Environmental variables

Results of environmental variables from the overlying waters and sediment in the TGOSFP were already described in detail in Tran et al. [8]. A PCA was performed based on the different environmental variables (axis 1 explains 29.70 % and axis 2 explains 21.30 % of the variation). Results showed that the dry season was separated from other seasons, salinity was the main factor responsible for the differences found between dry and other seasons. Addition, salinity was a main environmental variable in the dry season, whereas the trans and wet seasons were governed by Fe^{2+}, Fe^{3+}, TN, TOC, DO, pH, and depth (Fig. 3).

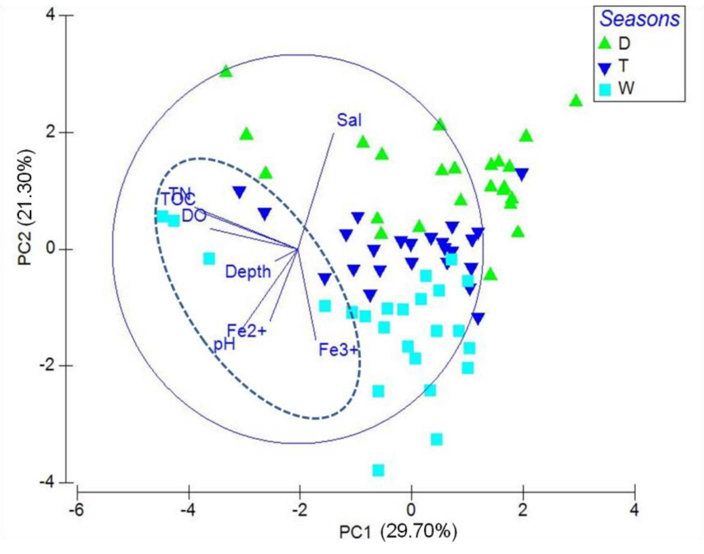

Figure 3. Principal Component Analysis (PCA) based on normalized environmental variables for all ponds in dry (D), trans (T) and wet season (W).

The two - way ANOVA showed significant differences for seasons, ponds and the interaction terms seasons × ponds effect on salinity and pH at the 95 % confidence level.

However, significant differences between seasons and ponds for TN were found. Furthermore, Fe^{3+} has a statistically significant on one factor (seasons). By contrast, the significant differences for ponds effect on DO and TOC (Table 1).

Environmental variables in the TGOSFP may not create an optimal condition for shrimp farming. The value of environmental variables in the TGOSFP compared with the standards of environmental quality parameters for shrimp farming (Table 2). Most variables (pH, DO, salinity, TN, and TOC) were over the recommended limits for environmental quality variables of shrimp culture, which might be resulted in poor production. Nguyen et al. [7] have warned that pH values of the sediment in most of the shrimp farm ponds in Mekong Delta ranged from slightly acidic to neutral that was lower than those in the standards and values reported in Thailand (8.14 - 8.29) [32]. The values of DO were still in the standards but sometimes was lower than the optimal range for shrimp farming during three seasons. The high percentage of TN and TOC were recorded and that are higher than the standards. The concentration of TN (%) in the TGOSFP was higher than observed in Honduras (0.17 - 0.28 %) [33], Bangladesh (0.11 - 0.18 %) [34] and Ecuador (0.02 - 0.52 %) [35]. The best pH for decomposition of organic matter should be varied from 7.5 to 8.5 [36] but pH in the TGOSFP was low. This constitutes an explanation of the high percentage of TN and TOC. Add further disadvantage for the TGOSFP, the anaerobic condition was recorded in all ponds (evidenced by higher Fe^{2+} as compared with Fe^{3+}). This condition can release of toxic substances (e.g. H_2S) into pond water [37] and explains why the concentration of TN and TOC were high.

Table 2. Criteria and standards of environmental quality parameters for shrimp farming.

Environmental parameters	In the TGOSFP	Optimum value	References
pH	6.69 - 7.54	7.00 - 8.00	[38]
DO	4.50 - 13.50 mg/l	3.50 – 6.00 mg/l	[38]
TN	0.20 - 0.43 %	0.20 - 0.28 %	[33]
TOC	2.80 - 7.30 %	1.50 - 2.50 %	[39]

3.3. Dominant nematode genera determined by SIMPER analysis

The results of the SIMPER analysis showed the average abundances of dominant genera and their contribution in the TGOSFP were showed in Table 3. The most dominant genera belong to ten families such as Xyalidae, Desmodoridae, Chromadoridae, Linhomoeidae, Neotonchidae, Oxystominidae, Axonolaimidae, Cyatholaimidae, Comesomatidae, and Sphaerolaimidae. In dry, genus *Daptonema, Desmodora, Dichromadora, Ptycholaimellus, Terschellingia, Gomphionema, Halalaimus, Pseudolella, Parodontophora, Sabatieria,* and *Sphaerotheristus* were known as the dominant genera, in which *Terschellingia* and *Daptonema* were the two most dominant genera (33.29, 18.07 %, respectively). Results of the SIMPER shows the dominant genera in trans, such as *Daptonema, Dichromadora, Eumorpholaimus, Terschellingia, Gomphionema, Pseudolella, Parodontophora, Pomponema, Sphaerolaimus, Sphaerotheristus* and *Subsphaerolaimus* in which *Daptonema, Terschellingia,* and *Pseudolella* were also known as the three most dominant genera (19.7, 25.47 and 16.35 %, respectively). In addition, several genera such as *Daptonema, Dichromadora, Terschellingia, Gomphionema, Halalaimus, Pseudolella, Parodontophora,* and *Sphaerotheristus* in which *Terschellingia, Daptonema,* and *Parodontophora* were the three most dominant genera (30.61, 20.79 and 11.72

%, respectively). Several genera like *Daptonema*, *Dichromadora*, *Terschellingia*, *Parodontophora*, *Sphaerotheristus* were easily distinguished as the dominant genera during the study period. By contrast, *Desmodora* (dry), *Eumorpholaimus, Pomponema* (trans), *Sabatieria* (dry), *Sphaerolaimus* and *Subsphaerolaimus* (trans) were referred to dominant only one season.

Table 3. The average abundances (A. Ab - ind/10 cm^2) of dominant genera and their contribution (Con - %) in Tam Giang's organic shrimp farms ponds.

Families and genera	Dry		Trans		Wet	
	A. Ab	Con	A. Ab	Con	A. Ab	Con
Xyalidae	219.22	18.07	919.22	19.7	429.72	20.79
Daptonema (Dap)	219.22	18.07	919.22	19.7	429.72	20.79
Desmodoridae	38.98	1.62	-	-	-	-
Desmodora (Des)	38.98	1.62	-	-	-	-
Chromadoridae	155.21	13.11	218.82	5.66	204.03	9.09
Dichromadora (Dic)	39.62	3.66	218.82	5.66	134.96	7.16
Ptycholaimellus (Pty)	115.59	9.45	-	-	69.07	1.93
Linhomoeidae	289.14	33.39	1,194.24	27.84	556.16	30.61
Eumorpholaimus (Eum)	-	-	205.48	2.37	-	-
Terschellingia (Ter)	289.14	33.39	988.76	25.47	556.16	30.61
Neotonchidae	68.03	2.91	121.33	1.97	92.6	4.13
Gomphionema (Gom)	68.03	2.91	121.33	1.97	92.6	4.13
Oxystominidae	33.98	1.69	-	-	73.73	2.64
Halalaimus (Hal)	33.98	1.69	-	-	73.73	2.64
Axonolaimidae	210.28	15.77	689.33	25.21	338.25	19.12
Pseudolella (Pse)	110.48	5.84	417.16	16.35	126.65	7.4
Parodontophora (Par)	99.8	9.93	272.17	8.86	211.6	11.72
Cyatholaimidae	-	-	142.75	2.93	-	-
Pomponema (Pom)	-	-	142.75	2.93	-	-
Comesomatidae	46.45	3.28	-	-	-	-
Sabatieria (Sab)	46.45	3.28	-	-	-	-
Sphaerolaimidae	18.17	1.17	273.64	6.99	87.84	3.85
Sphaerolaimus (S. mus)	-	-	70.86	2.2	-	-
Sphaerotheristus (S.tus)	18.17	1.17	95.37	2.44	87.84	3.85
Subsphaerolaimus (Sub)	-	-	107.41	2.35	-	-

(- means average abundances and contribution were low as compared with other genera within seasons)

3.4. The correlation between dominant nematode genera and environmental characteristics

Results of the SIMPER recorded fifteen dominant genera in three seasons and were included in data analysis using CCA. The CCA was done to identify the multivariate ordination of the main environmental variables driving force that govern the dominant genera abundances.

The results showed that individual genus responds differently to these variables. More specifically, in dry seasons, the first 2 axes explained about 54.4 % of the variance for FLNC (Axis 1 accounting for 36.2 %, axis 2 accounting for 18.2 % of the variance). Axis 1 was positively ordained with TN, TOC, depth and salinity and lesser extent with DO. The trends of main environmental variables (TN, TOC, depth, and salinity) were regulated in several genera such as *Desmodora*, *Terschellingia*, and *Sabatieria* (Fig. 4A). In the trans season, axis 1 which explained about 37.4 % of the variance, was positively ordained with TOC and Fe^{2+} but negatively with salinity, whereas axis 2 (account for 21.9 %) was related to depth and lesser extent with DO. The trends regulated TOC and salinity governed *Dichromadora*, *Pomponema*, and *Pseudolella* (Fig. 4B). In the wet season, results of CCA analysis showed that the first 2 axes explained about 61.4 % of the variance (Axis 1, 2 accounting for 37, 24.4 %, respectively). The axis 1 was positively ordained with TN, TOC and DO but negatively ordained with salinity, whereas axis 2 was related to pH. The trends of main environmental characteristics (TN, TOC, DO and salinity) were regulated in several genera such as *Sphaerotheristus*, *Terschellingia*, *Ptycholaimellus* and *Halalaimus* (Fig. 4C).

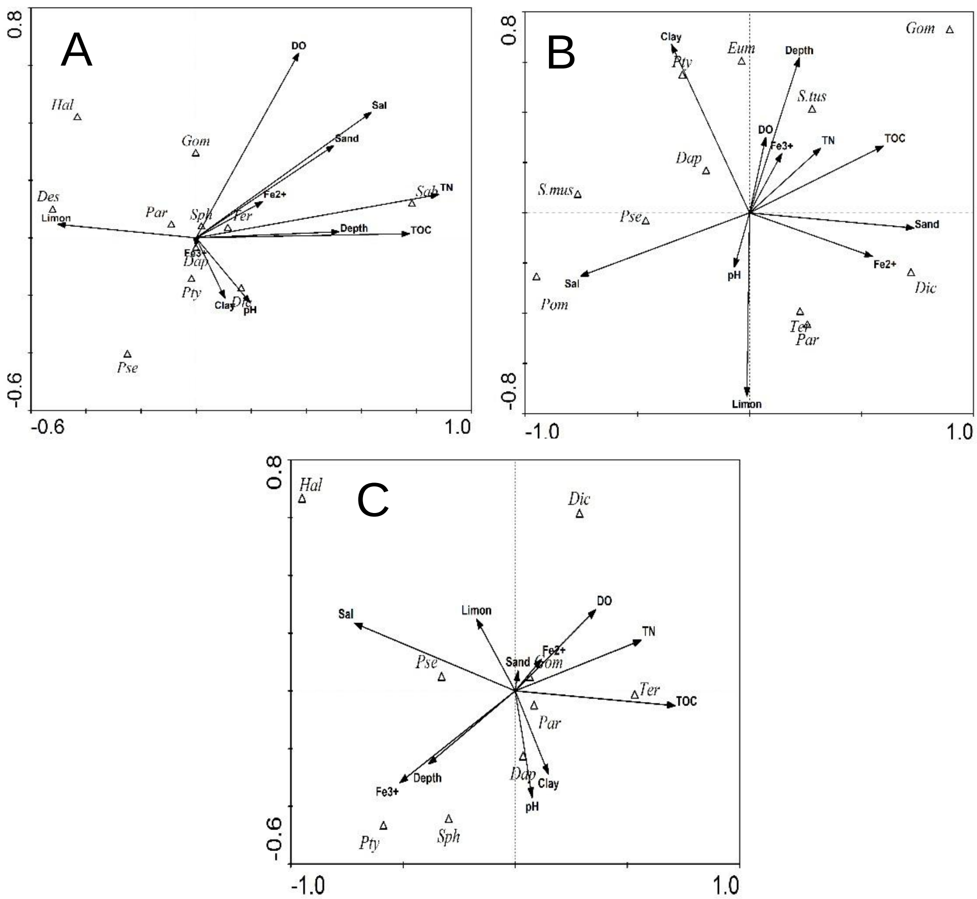

Figure 4. Canonical correspondence analysis (CCA) based on normalized environmental characteristics for several dominant genera in dry (A), trans (B) and wet season (C).

Overall, the results of CCA analysis showed that main environmental characteristics, such as TN, TOC, depth, DO, salinity, and pH almost completely governed the dominant genera such as *Desmodora, Sabatieria, Terschellingia, Dichromadora, Pomponema, Halalaimus, Ptycholaimellus,* and *Sphaerotheristus*. Subsequently, we conducted a Pearson correlation analysis between main environmental characteristics and several dominant genera. The results confirmed that the abundances of genus *Sabatieria*, *Terschellingia* were significantly positively correlated with TOC, TN, and depth. In contrast, genera like the *Desmodora*, *Halalaimus,* and *Ptycholaimellus* showed negative correlations with organic enrichment (TOC and TN). Besides, most dominant genera were positively correlated with salinity (Table 4).

Table 4. Pearson correlations (r - %) and p-value between environmental characteristics with the abundances of several dominant genera (only significant variables were showed).

Genera	TOC	TN	Depth	Salinity
Desmodora	-48.58 (0.02)	-54.53 (<0.01)	-41.42 (0.04)	-
Sabatieria	44.32 (0.03)	53.63 (0.01)	-	43.65 (0.03)
Terschellingia	61.58 (<0.01)	47.21 (0.02)	42.78 (0.04)	-
Dichromadora	45.58 (0.02)	-	-	-
Pomponema	-	-	-	46.41 (0.02)
Halalaimus	-46.43 (0.03)	-	-	76.09 (0.00)
Ptycholaimellus	-	-42.53 (0.04)	-	-
Sphaerotheristus	-	-	-	40.66 (0.04)

(- means no significant correlations)

3.5. The ecological quality status of sediment was indicated by the dominant nematode genera and MI value

The present study, the two genera *Desmodora,* and *Halalaimus* were revealed negative correlations with organic enrichment. Similar results have been reported by Moreno et al. [40] in the Mediterranean Sea. These genera selected as indicators of moderate and pristine habitats (e.g. *Desmodora*, *Halalaimus*) [40]. However, *Terschellingia* and *Sabatieria* have been credited was as the most dominant genus in all ponds. These genera were selected as indicators of pollution and organic enrichment conditions [41]. Some of the information discussed above may well diagnose that the TGOSFP's sediment was enriched with organic matter and nitrogen. The EcoQ were evaluated according to Moreno et al. [40], who proposed the EcoQ into three categories based on MI value using the following criteria: High EcoQ with MI value > 2.8, good EcoQ with 2.8 ≥ MI > 2.6, moderate EcoQ with 2.6 ≥ MI > 2.4, poor EcoQ with 2.4 ≥ MI > 2.2 and bad EcoQ with MI value ≤ 2.2 . The EcoQ in the TGOSFP was shown in Fig. 2. In general, the results indicated that most of the TGOSFP were classified from moderate to poor EcoQ. Addition, the EcoQ would likely be deteriorated between three seasons (except for pond P1, P6, and P7). The wet season has been credited with the highest percentage of Fe^{2+}, Fe^{3+}, TN, and TOC. It could be one of the major reasons why the EcoQ in wet season was classified as bad and poor in most ponds (except P6). Analysis of the FLNC at the level of genus revealed the best correspondence between environmental characteristics and biological response. The application of these genera may also be used as indicators about the organic enrichment of the TGOSFP's sediment.

4. CONCLUSION

Free-living nematode communities in the TGOSFP was characterized by high density and diversity. It provided a rich natural food source for shrimp diet. Nevertheless, the environmental characteristics in the TGOSFP attributed by a high percentage of TN and TOC, low pH and anaerobic condition in sediment that were not optimal conditions for shrimp farming, and might result in poor production. In addition, results of the present study showed that the abundances of dominant nematode genera in this area were influenced by a group of an environmental variables. The attribute of FLNC and their correspondence with environmental variables can be considered as a good tool for environmental monitoring. These results could have provided useful information to better understand the correlation between biotic and abiotic factors in organic shrimp farms ponds. Results of this study have also created valuable baseline data for sustainable development of the model organic shrimp farms in the Mekong Delta of Viet Nam.

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