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Seasonal dynamics of meiofaunal distribution in the Dagu River Estuary, Jiaozhou Bay, China

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Abstract

Sediment samples were collected in the intertidal zone of the Dagu River Estuary, Jiaozhou Bay, China in April, July and October 2010 and February 2011 for examining seasonal dynamics of meiofaunal distribution and their relationship with environmental variables. A total of ten meiofaunal taxa were identified, including free-living marine nematodes, benthic copepods, polychaetes, oligochaetes, bivalves, ostracods, cnidarians, turbellarians, tardigrades and other animals. Free-living marine nematodes were the most dominant group in both abundance and biomass. The abundances of marine nematodes were higher in winter and spring than those in summer and autumn. Most of the meiofauna distributed in the 0–2 cm sediment layer. The abundance of meiofauna in high-tidal zone was lower than those in low-tidal and mid-tidal zones. Results of correlation analysis showed that Chlorophyll *a* was the most important factor to influence the seasonal dynamics of the abundance, biomass of meiofauna and abundances of nematodes and copepods. CLUSTER analysis divided the meiofaunal assemblages into three groups and BIOENV results indicated that salinity, concentration of organic matter, sediment sorting coefficient and sediment median diameter were the main environmental factors influencing the meiofaunal assemblages.

Key words: meiofauna, seasonal dynamics, tidal flat, Dagu River Estuary, Jiaozhou Bay, China

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1 Introduction

The term “meiofauna” is widely defined as a group of aquatic benthic animals with microscopically small size, which could be found in most marine and fresh water environment. In sorting operation, meiofauna is the benthic animals that can pass through 0.5 mm mesh but retained by 0.042 mm mesh (deep-sea ecology researchers suggest 0.031 mm mesh to be lower limit; Higgins and Thiel, 1988; Giere, 2009). Due to their small size, high abundance and fast turnover rates, meiofauna are considered to be important component of ecological system, especially in estuarine ecological system. Meiofauna are thus considered to be important factor in both ecological food web and recycling of nutrients (Heip et al., 1988; Coull, 1999). Previous reports showed that the metabolic activities of meiofauna significantly influence the substance metabolism and energy flow processes in the benthic environment (Montagna et al., 1995). Estuary as a transition area of marine and freshwater environment has a unique ecological system in terms of its function of mixing marine and brackish water and supporting the high level of biodiversity. In addition, meiofauna is widely regarded as the indicator in assessing the marine pollution due to their high sensitivity to environmental variation. However, there are some obstacles in terms of methodology in examining the distribution and dynamics of meiofauna community, including extracting fragile organisms from sediments for quantitative analyses. The new methodologies have combined silica sol density gradient centrifugation and the quantitative protargol stain (QPS) to realize quantitative investigations of the benthic ciliate assemblages (Hamels et al., 2004, 2005; Wickham et al., 2000; Xu et al., 2010).

The Jiaozhou Bay is a 32 km long and 27 km wide semi-enclosed bay, located in Shandong Peninsula in eastern China. However, the rapid urbanization and increasing population are threatening the sustainability of the ecological situation in the Jiaozhou Bay. According to the survey of China State Oceanic Administration, the surface area of the Jiaozhou Bay has decreased from 560 km^2 in 1982 to 362 km^2 by 2003 due to sustained land reclamation activities in recent decades. Meanwhile, the marine species also sharply decreased. The Dagu River is the largest river flowing into the Jiaozhou Bay and the estuary of Dagu River becomes one of the most important ecosystems along the Jiaozhou Bay. As a consequence, a nature reserve has been established in this area (Ministry of Environmental Protection of the People’s Republic of China, 2010) to protect the local environment.

Most of the previous studies conducted in the Dagu River Estuary focused on plankton or macrofauna (Yuan et al., 2007; Zhang et al., 2001), and there are limited reports discussing seasonal dynamics of meiofaunal distribution in this area. The present study aims to analyze the impacts of season-varied environmental parameters on meiofaunal distribution in order to understand the current situation of the Dagu River Estuary ecologic-

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al environment, which not only to study the ecology of meiofauna in the Dagu River Estuary but also to further provide evidences for the implementation of coastal protection.

2 Materials and methods

In order to investigate the seasonal variation of meiofauna community, sediment samples were collected for four times in April, July, October 2010, and February 2011. Sediments were collected in high tidal zone, mid tidal zone and low tidal zone. For each zone, three sampling sites were randomly chosen. These sites were located at 36°10.443′–36°10.841′N, 120°08.407′–120°08.618′E (Fig. 1). At each sampling site, undisturbed sediments were collected and sectioned carefully using modified syringe with an inner diameter of 29 mm for three times, all the sediments were divided into three parts vertically (0–2 cm, 2–5 cm and 5–8 cm). Sediments, which would be used for meiofaunal distribution examination, were fixed with 5% formaldehyde. Other sediment samples were stored in lightproof refrigerating box without any additive and after returning to laboratory stored in –20°C for later environmental analysis. Additionally, interstitial water at each site was collected for salinity and pH analysis by refractometer and pH meter (DELTA320). Surface sediments were also sampled for analysis of grain size. At each site, the *in situ* temperatures were measured using a thermometer immerged into sediment to certain depth.

Meiofauna was stained with Rose Bengal and extracted from the sediment by the Ludox centrifugation technique (Heip et a1., 1988). Prior Ludox centrifugation process, elutriation and salt reduction were performed, during which a 500 μm mesh was used for removal of macrofauna and other organisms. Meiofauna was washed into a lined petri dish, then sorted and counted to taxon levels under a stereoscopic microscope according to Higgins and Thiel (1988) and Giere (2009). Meanwhile, the abundance and biomass of meiofauna were analyzed for each sample. The abundances of identified meiofaunal taxa were standardized as ind./(10 cm^2). The biomass of different meiofaunal group refers to some similar literature, and individual dry weight values and specific coefficient was used to calculate biomass of meiofauna (Widbom, 1984; Liu et al., 2005).

The analysis of sediment organic matter content was based on the methods stated in the Specification for oceanography survey-marine geology and geophysics survey (General Administration of Quality Supervision, Inspection and Quarantine of the PRC, 2007) using $K_2Cr_2O_7$-H_2SO_4 oxidization method (Gaudette et al., 1974; Nelson and Sommers, 1982). The concentration of sediment chlorophyll *a* (Chl *a*) was measured according to the methods of extraction fluorescence (Liu et al., 2007).

The abundance of meiofauna was defined as individual per 10 cm^2 and calculated by each layer and site. The environmental parameters were sediment depth (cm), water temperature (°C), salinity, pH, median diameter (mm), sediment sorting coefficient, concentration of Chl *a* (mg/kg) and content of organic maters (%). In order to assess relationships among the meiofaunal abundance and environmental parameters, Pearson correlation analyses were performed using SPSS 16.0 statistical software package.

In order to further identify the similarity between meiofauna and the importance of different environmental factors on the seasonal distribution of biota, the Hierarchical clustering (CLUSTER) analysis, similarity profile (SIMPROF) permutation test and BIOENV analysis were introduced into the data analysis process using PRIMER 6 (Plymouth Routines in Multivariate Ecological Research) software package (Clarke and Gorley, 2006). The Bray–Curtis coefficient (Bray and Curtis, 1957) was used in calculating the similarity between meiofaunal assemblages divided by sampling seasons and sites. Before coefficient calculation, in order to reduce bias caused by a unique high value for a certain species, the data were fourth-root transformed (Clarke and Warwick, 2011). The meiofaunal assemblages of the sampling sites were delineated into different groups using Hierarchical clustering (CLUSTER) analysis and similarity profile (SIMPROF) permutation test. The spatial differences of meiofaunal assemblages were further correlated with the environmental factors, using the analysis method matching of Biota and Environmental factors (BIOENV), which calculated the Spearman rank correlation coefficients between faunal and environmental factors.

3 Results

The trend of temperature showed a typical temperature variation of temperate zone in the northern hemisphere, which reached bottom in April 2010 and constantly increased to 28°C in July 2010, then reduced in autumn and winter with a minimum of 7°C in February 2011. The pH of interstitial water ranged from 7.37 to 8.30 at the three different zones. The pH value increased in turn from high tidal zone to low tidal zone, which conformed

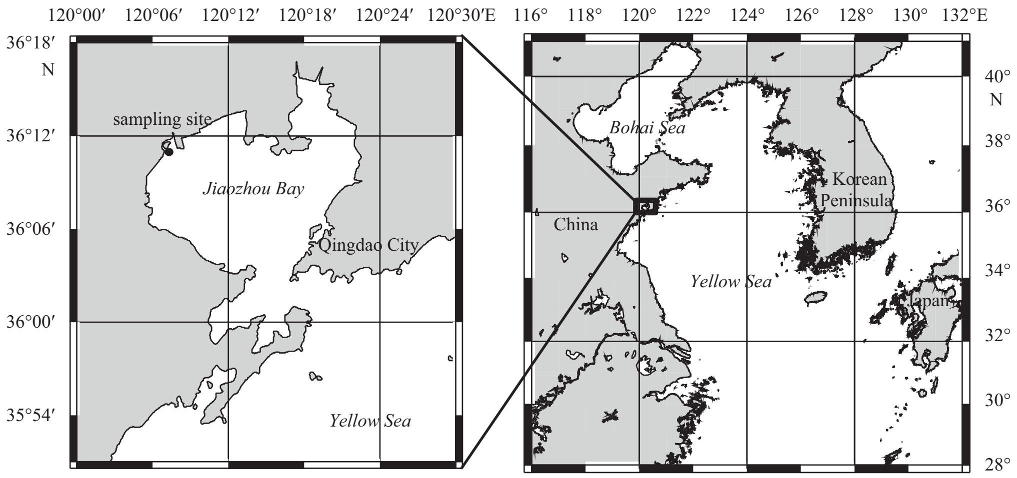

Fig. 1. Map of the Jiaozhou Bay, China, showing the location of sampling site in the Dagu River Estuary.

to the fact that low tidal zone is more influenced by seawater. Unlike the pH value, such pattern had not been found for the salinity variation of interstitial water, which ranged from 27 to 30 in the three zones. Salinity values in spring and winter were a little higher than those in summer and autumn, which may be caused by the flood of the Dagu River.

Sediment median diameter increased in the order of high tide, mid tide and low tide. Especially in low tidal zone, the median diameter of sediment was significantly higher (Table 1). Meanwhile, the main sediment compositions in the three zones were clay, silt and sand. The proportion of clay and silt remained relatively constant in the three zones. However, the proportion of sand increased in turn from the high tidal zone to the low tidal zone.

The data of chlorophyll concentrations in winter high tidal zone were not listed due to missing of those samples. However, Fig. 2b showed that the concentration of Chl *a* increased in winter and spring. The variation tendency of Chl *a* showed seasonality that in the 0–2 cm surface layer, spring (7.8 mg/kg)>summer (3.0 mg/kg) ⩾ winter (2.9 mg/kg)>autumn (2.5 mg/kg); in 2–5 cm subsurface layer and 5–8 cm deep layer the variation of Chl *a* concentration is not limited (Fig. 2).

Table 1. Sediment characteristics of the intertidal sampling zones in the Dagu River Estuary

Sampling location	Grain size distribution/%				QD_Φ	SK_Φ	MD/mm	Sediment type
	Sand	Silt	Clay	Silt+Clay				
High tidal zone	4.98	65.64	29.39	95.03	1.87	0.07	0.001	clayey silt
Middle tidal zone	31.44	53.40	15.17	68.56	2.14	0.43	0.03	sandy silt
Low tidal zone	49.02	38.17	12.82	50.99	2.27	0.50	0.520	silty sand

Note: QD_Φ is the separation factor, SK_Φ skewness, and MD median diameter.

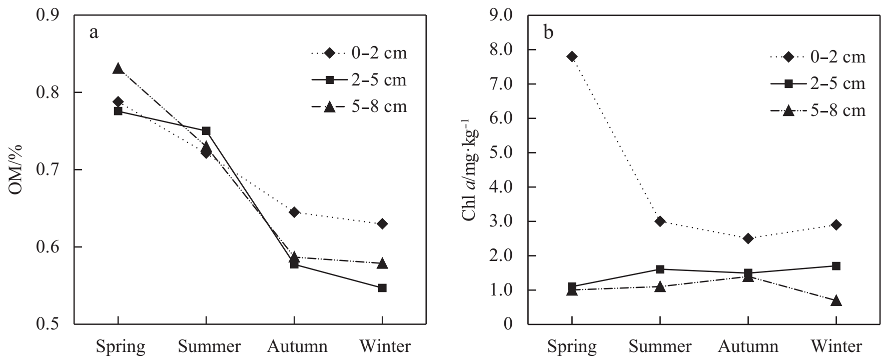

Fig. 2. Seasonal variation of organic matter content (a) and Chl *a* (b) in sediment of the Dagu River Estuary.

The content of organic matter reached maximum of 1.43% at high tidal zone and minimum of 0.4% at mid tidal zone both in summer (Fig. 2). Vertically, in high tidal zone organic matter content decreased in order of surface layer, subsurface layer and deep layer. On contrast, in the other zones, no such pattern has been observed. In addition, the organic matter content in high tidal zone was significantly higher than those in the other two zones. No significant differences between mid tidal zone and low tidal zone were found. Details about seasonal variation and vertical distribution of organic matter (OM) content and Chl *a* in sediment are shown as Table 2.

In the present study, ten kinds of meiofauna taxa were identified, including Nematoda, Copepoda, Polychaeta, Oligochaeta, Bivalvia, Ostracoda, Cnidaria, Tubellaria, Tardigrada and others. The biomass and abundances of each meiofauna taxa are listed in Table 3 and Table 4. Figure 3a shows the change of biomass in different seasons.

The composition of meiofaunal taxa in different seasons was showed in Fig. 3e, which suggested that nematode was the dominant group all over the year and followed by copepod. These two taxa constituted the majority of biomass, especially in autumn and summer, which accounted for around 95%. In winter and spring, their dominance was still obvious although the percentage decreased.

Horizontally, meiofaunal abundance reduced gradually from low tidal zone to high tidal zone, in terms of both quantity and number of taxa. Some seasonality of abundance distribution has been observed especially in the low tidal zone. The peak of the

Table 2. Seasonal variation and vertical distribution of organic matter (OM) content and Chl *a* in sediment

	Spring									Summer								
	High tidal zone			Middle tidal zone			Low tidal zone			High tidal zone			Middle tidal zone			Low tidal zone		
Sediment depth/cm	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8
OM/%	1.4	1.2	1.2	0.5	0.6	0.7	0.5	0.5	0.6	1.4	1.4	1.4	0.4	0.3	0.4	0.4	0.5	0.5
Chl *a*/mg·kg^{-1}	3.7	0.6	0.5	6.8	0.8	1.0	12.7	1.8	1.6	4.5	2.4	1.4	2.5	1.2	0.8	2.0	1.1	1.2
	Autumn									Winter								
	High tidal zone			Middle tidal zone			Low tidal zone			High tidal zone			Middle tidal zone			Low tidal zone		
Sediment depth/cm	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8
OM/%	1.0	1.1	1.0	0.5	0.4	0.3	0.4	0.3	0.4	1.1	1.0	0.9	0.4	0.3	0.4	0.4	0.3	0.4
Chl *a*/mg·kg^{-1}	3.4	2.5	2.7	1.8	1.1	0.5	2.2	0.8	0.9	–	–	–	4.6	0.7	0.4	1.1	2.7	1.0

Table 3. Average meiofaunal biomass (μg/(10 cm^2)) and the vertical distribution, percentage of each meiofaunal taxa

Sediment depth/cm	High tidal zone			Middle tidal zone			Low tidal zone			Percentage/%
	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	
Nematode	133.3	63.2	34.1	414.3	88.6	78.8	807.4	206.6	225.6	71.97
Copepod	8.6	8.1	9.1	50.9	4.7	3.3	82.1	21.2	2.8	6.69
Polychaete	0.0	0.0	1.8	0.0	1.8	1.8	10.5	14.0	0.0	1.04
Oligochaete	0.0	1.8	0.0	1.8	1.8	0.0	3.5	0.0	1.8	0.37
Bivalve	0.5	0.0	0.0	1.6	2.6	5.8	11.0	18.9	7.9	1.69
Ostracod	0.0	0.0	0.0	3.3	13.0	0.0	182.0	35.8	3.3	8.32
Copepod larvae	11.0	2.1	1.6	4.2	0.5	0.0	8.4	2.6	0.5	1.09
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.02
Planarian	0.9	0.0	0.0	3.0	0.0	0.0	0.9	0.0	0.4	0.18
Tardigrade	0.0	0.0	0.0	1.3	0.0	0.0	0.9	0.0	0.0	0.08
Others	3.5	0.0	2.6	125.6	4.4	4.8	93.2	4.4	5.3	8.55
Total	157.8	75.2	49.1	605.9	117.2	94.3	1 199.8	303.9	247.5	100.00

Table 4. Average meiofaunal abundance (ind./(10 cm^2)) and the vertical distribution, percentage of each meiofaunal taxon

Sediment depth/cm	High tidal zone			Middle tidal zone			Low tidal zone			Percentage/%
	0–2	2–5	5–8	0–2	2–5	5–8	0–2	2–5	5–8	
Nematode	133.3	63.2	34.1	414.3	88.6	78.8	807.4	206.6	225.6	86.76
Copepod	7.0	6.6	7.4	41.5	3.8	2.6	66.9	17.2	2.3	6.56
Polychaete	0.0	0.0	0.2	0.0	0.2	0.2	1.1	1.5	0.0	0.14
Oligochaete	0.0	0.2	2.0	0.2	0.2	0.0	0.4	0.0	0.2	0.13
Bivalve	0.2	0.0	0.0	0.6	1.0	2.1	4.0	6.8	2.8	0.74
Ostracod	0.0	0.0	0.0	0.2	0.8	0.0	10.6	2.1	0.2	0.58
Copepod larvae	4.0	0.8	0.6	1.5	0.2	0.0	3.0	1.0	0.2	0.47
Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Isopod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.01
Planarian	0.4	0.0	0.0	1.3	0.0	0.0	0.4	0.0	0.2	0.10
Tardigrade	0.0	0.0	0.0	0.6	0.0	0.0	0.4	0.0	0.0	0.04
Others	1.5	0.0	1.1	54.3	1.9	2.1	40.3	1.9	2.3	4.46
Total	146.3	70.8	45.4	514.5	96.5	85.7	934.4	237.3	233.8	100.00

abundance appeared in winter and spring and a reduce trend was found in the following summer and autumn (Fig. 3c).

The results of Pearson correlation analysis indicated that there were significant correlations between meiofaunal abundance and sediment depth, content of organic matter, percentage of silt and clay, temperature and salinity. Meanwhile, significant positive correlations between meiofaunal abundance and sites, concentration of Chl *a* and pH were also observed (Table 5). The results of BIOENV analysis indicated that salinity, concentration of organic matter, sediment sorting coefficient and median diameter were the main environmental factors that influenced the distribution of the meiofaunal abundance (Spearman correlation coefficient 0.430, p<0.05; Table 6).

According to the results of CLUSTER analysis, the sampling sites in different seasons and tidal zones were classified into three groups at 60% similarity level (Fig. 4), with significant differences from the SIMPROF test (p<0.05). The first group included the three sites sampled in spring (Sites H1, M1 and L1), the second group included the two sites sampled in winter (Sites M4 and L4) and one each in summer and autumn (Sites L2 and L3), while the third group included the two each sites sampled in summer and autumn (Sites H2, M2, H3 and M3) and one in winter (Site H4) with low similarity. This result indicated the meiofaunal assemblages in summer and autumn was much similar with each other, especially in the low tidal zone (Sites L2 and L3). The meiofaunal assemblages in winter were more similar than those in spring.

4 Discussion

The concentration of OM in sediment is regarded as one of the sentinels of environmental pollution. Some taxa of meiofauna feed on sediment organic matter. As a consequence, the concentration of OM is one of the essential environmental parameters influencing the distribution of meiofauna. The results of the present study indicated that the concentration of OM in high tidal zone was much higher than those in mid and low tidal zone with a significant positive relationship to the content of silt and clay in sediments. The seasonal variation of OM concentration was slight, ranged from 0.5% to 0.8%, which indicate the pollution level of this region was not high. The Dagu River watershed covers several villages and agricultural land before discharging into the Jiaozhou Bay and the estuary area is important for receiving and absorbing the domestic sewage and fertilizer residues, which may lead to the slight change of the concentration of OM in the Dagu River Estuary. Furthermore, the Dagu River Estuary is widely used as aquaculture sites for clams (*Ruditapes philippinarum*). The aquaculture activities were reported as changing the concentration of OM in sediment and further influence the dynamics and component of meiofaunal assemblages (Zhang et al., 1993; Dang et al., 1996).

The concentration of Chl *a* is commonly used in estimating the benthic microalgal biomass, which is important food supply

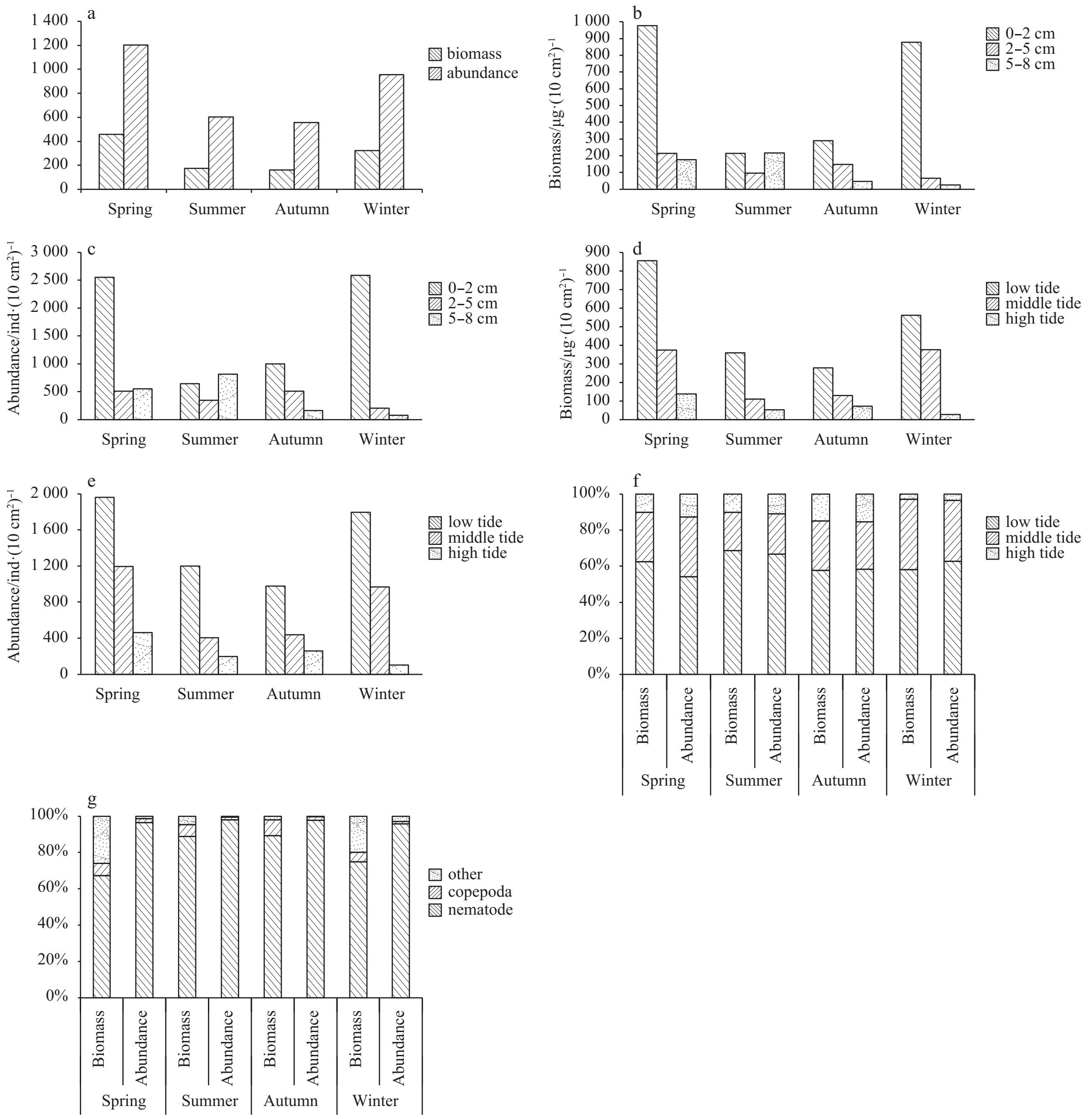

Fig. 3. Meiofaunal biomass (μg/(10 cm²)) and abundance (ind./(10 cm²)) changes of different seasons (a), vertical distribution of meiofaunal biomass (b), vertical distribution of meiofaunal abundance (c), horizontal distribution of meiofaunal biomass (d), horizontal distribution of meiofaunal biomass (e), seasonal dynamics of composition percentage of meiofaunal abundance in different tidal zones (f), and composition percentage of meiofaunal taxa in different seasons (g).

Table 5. Results of correlation analysis between abundance of meiofauna and environmental factors

Factor	TD	SD	OM	Chl *a*	Ab	S&C	pH	Salinity	*T*
OM	−0.745**	−0.043	–	0.096	−0.239*	0.813**	−0.812**	0.844**	0.061
Chl *a*	−0.008	−0.459**	0.096	–	0.514**	0.028	−0.014	0.280	−0.276**
Ab	0.410**	−0.433**	−0.239*	0.514**	–	−0.356**	−0.394**	−0.298**	−0.159

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed). TD represents tidal zone, SD sediment depth, OM organic matter, Ab meiofaunal abundance, S&C content of silt and clay, and *T* temperature.

for meiofauna (Grinham et al., 2007; Underwood and Kromkamp, 1999). The seasonal dynamics of Chl *a* in this research showed that the high concentration was observed in winter and spring while the concentration was relatively low in summer and autumn. This observation highly agreed with the results reported by Epstein (1997), which investigated the bloom of diatoms at the end of winter and spring as well as decline of diatoms abundance at mid-summer as a consequence of grazing by herbivores.

There are limited reports regarding the seasonal dynamic of meiofaunal distribution, especially in the Dagu River Estuary, Jiaozhou Bay. In the present study, the meiofaunal biomass peak

Table 6. Results of BIOENV analysis (matching of biota and environmental factors) between meiofanal assemblages and environmental factors

Number of environmental factors	Spearman correlation coefficient	Environmental factors
4	0.430	OM, QD, salinity, Md
3	0.423	QD, salinity, Md
3	0.416	OM, salinity, Md
2	0.411	salinity, Md
3	0.410	OM, QD, salinity

Note: OM represents concentration of organic maters, QD separation factor of sediment, and Md sediment median diameter.

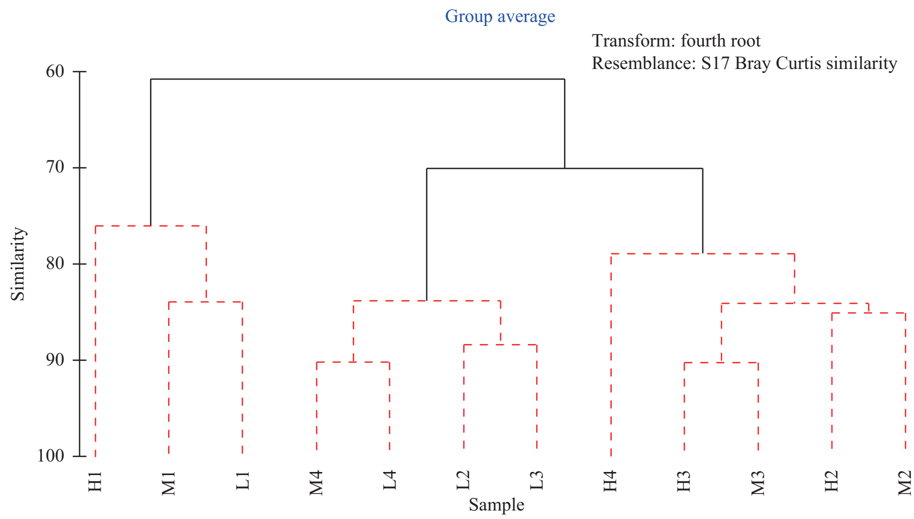

Fig. 4. Grouping of meiofaunal assemblages in spring, summer, autumn and winter based on CLUSTER analysis. Samples under different branches linked by black solid lines showed significant differences (SIMPROF, p<0.05) in assemblage structure, whereas samples in same branches linked by red dotted lines had no statistical differences (SIMPROF, p>0.05) in community structure. H/M/L stand for high/middle/low tidal zone and 1/2/3/4 stands for spring/ summer/autumn/winter seasons.

was observed in spring, followed by winter. The biomass in both of the seasons was significantly higher than those in summer and autumn. This result was in agreement with the results reported by Du et al. (2012) in the Dagu River Estuary, in which the high meiofaunal biomass was observed in February and March. The observations in the Beibu Gulf, China (Cai et al., 2012) also reported that the meiofaunal biomass researched the peak in spring, followed by winter.

The impacts of seasonal changing to the distribution of meiofauna are complicated. The seasonal changing functioned indirectly to the distribution of meiofauna by the variation of temperature, salinity (as a result of seasonal variation of rainfall and river input) (Lin et al., 2004; Chen et al., 2006), time span of sunlight, etc. Previous studies suggested that the distribution of meiofauna is either directly or indirectly in relation to temperature, as a consequence of temperature-influenced food abundance, water depth level. Additionally, the distribution of meiofauna is also influenced by salinity in the estuary area due to the huge variation range of salinity (Coull, 1999; Hourston et al., 2011; Kchaou et al., 2009). Results of the present study indicated that the positive correlation between meiofaunal biomass and concentration of Chl *a* as well as a negative correlation between concentration of Chl *a* and temperature. As a result, the biomass resulted in a relative high value in low-temperature seasons (winter and spring). The seasonal changing also reflects as the seasonal dynamic of river input changing the salinity and may eventually impact on the distribution of meiofauna, especially in estuary area. For the Dagu River, its flood seasons are summer and autumn, which lead to relative low salinity in these two seasons in the estuary area. Although the result of this research and some previous research (Cai et al., 2012) indicated a negative correlation between meiofaunal biomass and salinity, the high value of meiofaunal biomass was not shown in summer and autumn. Abovementioned observations suggest that food availability (concentration of Chl *a*) is the main control factors of the distribution of meiofaunal assemblages, which agreed with some previous studies (Danovaro and Gambi, 2002; Fonseca et al., 2011). This may be the consequence of the dominance of epistrate-feedering nematodes.

Additionally, besides the sediment conditions, the trophic interactions (e.g., species recruitment, competition and some potential predation stressors) are possible to play an important role in the dynamics of meiofaunal distribution in the study area. Meiofauna is often controlled by the macroepifauna through predator–prey relationships in food web (Bell, 1980; Brey, 1991; Dunn et al., 2013). The research of Zhang et al. (2001) reported a negative relationship between the biomass of meiofaunal and macrofauna through a year-round observation in the Jiaozhou Bay, which suggested the existence of the predator–prey relationships between meiofaunal and macrofauna. Therefore, the research conducted in the Dagu River Estuary by Du et al. (2012) suggested the competition between herbivorous nematodes and ciliates is also likely important in regulating the dynamics of meiofauna in the Dagu Rivers Estuary. The interactions between different trophic levels require further exploration by using stable isotope technique (Maria et al., 2011).

5 Conclusions

In the present study, we evaluated the relationship between the abundance and biomass of meiofauna and various environmental variables in different seasons and tidal zones in the Dagu River Estuary, Jiaozhou Bay. We found that salinity, concentration of organic matter, sediment sorting coefficient and median diameter were the main environmental factors influencing the distribution of meiofaunal assemblages, and accounted for the variation of seasonal distribution. However, further studies are needed especially for the identification of marine nematodes to reveal the controlling environmental factors affecting marine nematode assemblages.

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