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Composition, Abundance, and Diversity of the Peracarida on Different Vegetation Types in the Qi'ao-Dan'gan Island Mangrove Nature Reserve on Qi'ao Island in the Pearl River Estuary, China

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Chang-Fu Wang, Xian-Qiu Ren, and Run-Lin Xu (2010) Composition, abundance, and diversity of the Peracarida on different vegetation types in the Qi'ao-Dan'gan Island Mangrove Nature Reserve on Qi'ao Island in the Pearl River estuary, China. *Zoological Studies* **49**(5): 608-615. Almost nothing is known about the Peracarida in the Pearl River estuary. This is the 1st report to study the composition, abundance, and diversity of the Peracarida in the Qi'ao-Dan'gan I. Mangrove Nature Reserve on Qi'ao I., in the Pearl River estuary, southern China. Bimonthly samplings were carried out in 3 representative vegetation types (mangrove arbor, emergent plants, and seaweed) for 2 yr. Using a Peterson grab, 1940 individuals (ind.) were collected in total, including 11 species of 6 genera, 5 families, and 3 orders (Amphipoda, Isopoda, and Tanaidacean). *Discapseudes mackiei* Bamber 1997 was the dominant species with the highest density of 1,432 ind./m^2. The effect of temperature on the abundance of Peracarida was significant ($p < 0.01$), and the optimum temperature was 22-23°C in both the mangrove arbor and seaweed. The results showed that the abundance of the Peracarida was higher in the mangrove arbor, while the diversity, especially Amphipoda diversity, was higher in the seaweed. In contrast, emergent plants provided no suitable habitats for the Peracarida.
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Key words: Crustaceans, *Discapseudes mackiei*, Zoobenthos, Biodiversity.

The Peracarida is composed of small benthic crustaceans found from the littoral to hadal regions of the oceans, in addition to some that live in terrestrial and freshwater habitats (Holdich and Bird 1986, Jaume and Boxshall 2008). Members of the Peracarida are known to play important roles in structuring benthic assemblages (Duffy and Hay 2000) and are considered to be good bioindicators (Lourido 2008).

The Pearl River is the 2nd-largest river in China in terms of annual flow. Its drainage area covers 4.5 × 10^5 km^2, and the amount of discharge is about 350 × 10^9 m^3 annually (Chen et al. 2006). The Pearl River estuary is one of the largest river estuary systems in South China, with a north-south length of 49 km and an east-west width that varies from 4 to 58 km (Huang 2004). The Pearl River delta has been subject to heavy anthropogenic influences for decades. It is one of the most industrialized and economically significant regions in China and Southeast Asia. It has degenerated due to pollutants as a result of the rapid economic development and urbanization since the early 1980s (Chen et al. 2006).

There is a particularly rich benthic fauna due to a large diversity of sedimentary habitats. However, smaller macrobenthic invertebrates have been neglected in many previous studies,

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especially the Peracarida, although the larger macrobenthic fauna was investigated in detail in many parts of the Pearl River estuary (e.g., Huang et al. 2002, Liu et al. 2003). One reason to explain the lack of previous work is the difficulty of sampling in most parts of the Pearl River estuary which is badly polluted by sewage and heavy metals (Li et al. 2000 2001, Luo et al. 2008a). There are no macrobenthic invertebrates at all in some areas (Cai et al. 2007). In addition, it is difficult to identify the Peracarida, as some drawings of the original descriptions are vague or do not show all parts of the body (Schilling et al. 2006, Rehm et al. 2007), and some of the species show slight but consistent differences with specimens from the original descriptions. Moreover, some keys for identification are scarce in Chinese, especially on the Tanaidacean and Isopoda (Wei 1991, Du 1993).

The zoobenthos of aquatic systems is strongly affected by the presence and composition of vegetation within the water and on the waterside (Hernandez et al. 2005, Yoshimura and Maeto 2006). Leaf litter of seaweed (SW) and mangrove arbors (MAs) offers food and also provides habitats for the Peracarida to evade predators (Nakaoka 2002). However, few attempts have been made to investigate the relation between Peracarida assemblages and patterns of vegetation in the littoral zone (Pereira et al. 2006).

The purposes of this study were to scrutinize the assemblage patterns (composition, abundance, and diversity) on Qi’ao I. in the Pearl River estuary, and study the relationships between Peracarida assemblages and different types of flora. The authors wanted to lay a foundation for future biomonitoring activities in the Pearl River estuary.

MATERIALS AND METHODS

Sampling area

The sampling site was Qi’ao I., with an area of 23.8 km^2 situated about 1.2 km off the waterside (Fig. 1). In 2004, the Qi’ao-Dan’gan I. Mangrove Nature Reserve with 18.65 km^2 was established in order to protect the fauna and flora (Lei 2008). All sampling sites were within the Qi’ao-Dan’gan I. Mangrove Nature Reserve.

Three representative vegetation types, MA, emergent plants (EP), and SW were selected to analyze the effect of different vegetation types on the benthic Peracarida. The MA was dominated by mangrove trees, *Sonnerati acaseolaris* Buch-Ham and *Kandelia candel* (Linn.) Druce; the emergent plants were dominated by *Phragmites communis* Trin; and seaweed was dominated by *Myriophyllum* sp. All vegetation was natural.

The 3 sampling sites were comparatively close, with tens to hundreds of meters between each other. Close distances were selected in order to minimize physical and chemical discrepancies among sampling sites, such as temperature, salinity, current, chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), and heavy metals in the water and soil.

Sampling procedures

Quantitative sampling was done every 2 mo from Jan. 2007 to Nov. 2008 using a Peterson grab with a sampling area of 0.0625 m^2. Four replicates were taken at each station in order to achieve the minimum area necessary for a reliable investigation and to preserve the biotope for subsequent sampling. The samples were sieved through a 0.5 mm screen and preserved in a 4% diluted formalin solution. After 3 d, the samples were washed and transferred to 75% ethanol.

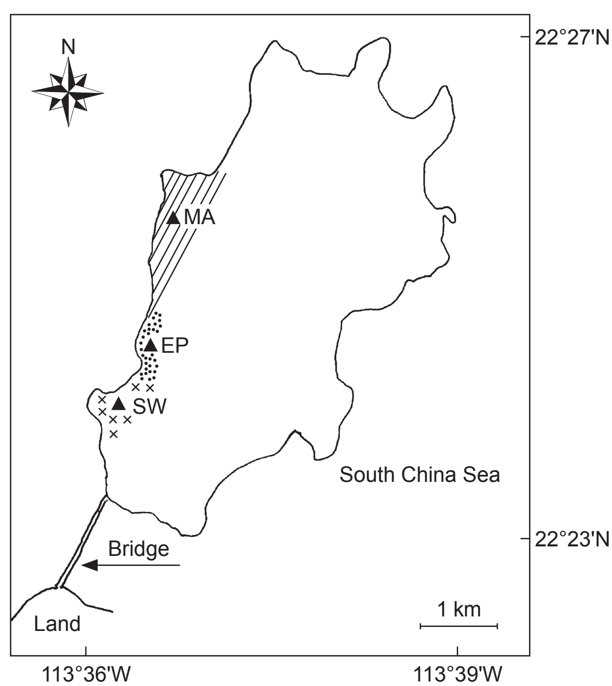

Fig. 1. Map of the study area and location of sampling sites on Qi’ao I. in the Pearl River estuary. MA, mangrove arbor; EP, emergent plants; SW, seaweed.

Sampling analysis

Individuals were sorted and dissected with the aid of a stereoscope (6-24×), and the appendages were observed under a microscope (100-400×). All specimens of the Peracarida were counted and identified to species level if possible. The Amphipoda was mainly identified according to Ren (2006), the Tanaidacean mainly according to Du (1993) and Bamber (1997), and the Isopoda mainly according to Wei (1991). COD, TN, TP, and heavy metals were surveyed at the 1st sampling in Jan. 2007 to serve as the baseline environmental values (Table 1). Water temperature and salinity were recorded at every sampling site and period (Table 2).

Data analysis

Shannon-Wiener diversity index (*H'*) (Shannon and Wiener 1949) and Pielou's evenness (*J'*) (Pielou 1966) were calculated on a $\log_2$ basis. Statistical analyses were performed using SPSS 11.5 software (SPSS, Chicago, IL, USA).

RESULTS

The total number of Peracarida collected was 1940 individuals (ind.), which were sampled with 12 Peterson grab replicates from Jan. 2007 to Nov. 2008. Except for 15 ind. of *Discapseudes mackiei* on Nov. 2007 and 2 ind. of *Paranthura japonica* Richardson, 1909 on Jan. 2008 in the EP, the remaining specimens were all sampled in the MA and SW (Table 3). Within the 3 habitats, 11 species including 6 genera and 5 families were found in total. The Amphipoda was the most diverse with 9 species, while there was only 1 species each of the Tanaidacea and Isopoda. All species found during the study were recorded in the SW, compared to 4 species in the MA and 2 species in the EP. Among the 11 species, only *D. mackiei* was found at all 3 stations (Table 3).

The abundance of specimens remarkably varied among stations (Table 3, Fig. 2). The most frequent was the Tanaidacea with 1710 ind. (88.1%), followed by the Amphipoda with 212 ind. (11%) and the Isopoda with 18 ind. (0.9%). In the MA, the abundance of the Peracarida was much higher than at the other 2 sites, in which the highest abundance was 1432 ind./m^2, only due to the contribution of *D. mackiei*, while 488 ind./m^2 in the SW was mainly due to the contribution of the Amphipoda. Abundance and diversity were lowest in the EP. The mean value of the Peracarida was 216 ind./m^2 on Qi'ao I. in the Pearl River estuary. Most specimens were sampled in spring, while the fewest specimens were recorded in summer and fall (Table 2).

In addition to values of 0 for the Shannon-Wiener index and Pielou's evenness in all samplings in the EP, the Shannon-Wiener index ranged 0-0.77 in the MA and 0-2.77 in the SW, Pielou's evenness ranged 0-0.67 in the MA and 0-0.99 in the SW, and both the Shannon-Wiener index and Pielou's evenness in the MA and SW lacked clear trends (Table 2, Fig. 3).

Variation of peracarid abundances with temperature was in accordance with a parabolic

Table 1. Physicochemical parameters of water and sediments on Qi'ao I. in the Pearl River estuary in Jan. 2007. MA, mangrove arbor; EP, emergent plants; SW, seaweed; COD, chemical oxygen demand; TN, total nitrogen; TP, total phosphorus

Physicochemical parameters	MA	EP	SW
COD (mg/l)	37.80	36.40	34.70
TN of water (mg/l)	1.54	1.52	1.49
TN of sediments (g/kg)	0.79	0.70	0.75
TP of water (mg/l)	0.058	0.061	0.068
TP of sediments (g/kg)	0.88	0.79	0.84
Pb of water (mg/l)	0.0060	0.0060	0.0060
Pb of sediments (mg/kg)	68.59	71.59	66.30
Zn of water (mg/l)	0.060	0.060	0.060
Zn of sediments (mg/kg)	187.01	206.85	175.05
Cu of water (mg/l)	0.011	0.012	0.011
Cu of sediments (mg/kg)	70.87	75.33	72.45

equation (Figs. 4, 5), $y = -14.41X^2 + 655.82X - 6451.90$ ($R^2 = 0.74$) in the MA and $y = -5.30X^2 + 242.31X - 2338.10$ ($R^2 = 0.87$) in the SW (Y, Peracarida abundance; X, temperature). Optimum temperatures of 22.76°C in the MA and 22.86°C in the SW resulted from these equations. The effect of temperature on Peracarida abundance was significant ($p < 0.01$, *F*-test).

DISCUSSION

Linking marine with both freshwater and terrestrial ecosystems, the estuary is characterized by plenty of food and transient environmental factors (Huang 2004). The unstable nature of this environment restricts the survival of faunal varieties, whereas sufficient food can support higher abundances of organisms. As a consequence, the macrozoobenthos of estuaries is considered to be of low diversity and high abundance (Holdich et al. 1983, Constable 1999, Cortelezzi et al. 2007). Similar results were found on Qi'ao I. in the Pearl River estuary in the present study.

In comparisons of Peracarida from shallow waters including 125 species in the subtidal zone of the Ría de Aldán, Spain (Lourido et al. 2008), 99 species in the western English Channel (Dauvin et al. 1994), and 61 species in the Ría de Aveiro, Portugal (Cunha et al. 1999), the species number on Qi'ao I. in the Pearl River estuary was very low with only 11 species. The main possible reasons are the heavy pollution of most rivers by industrial wastewater sewage and the pollution of the littoral by excessive marine aquiculture in China (Luo et al. 2008b). Most previous investigations in nearby regions found no Peracarida (e.g., Tam et al.

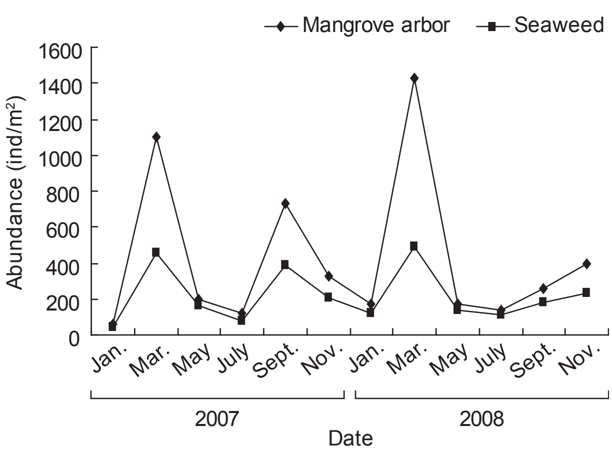

Fig. 2. Abundances of the Peracarida in the mangrove arbor and seaweed on Qi'ao I. in the Pearl River estuary.

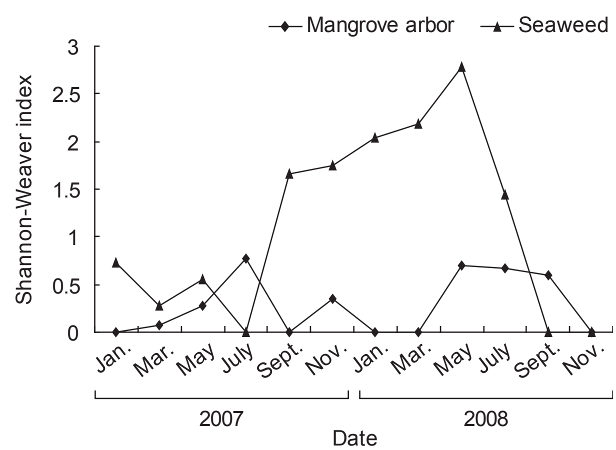

Fig. 3. Shannon-Wiener diversities of the Peracarida in the mangrove arbor and seaweed on Qi'ao I. in the Pearl River estuary.

Table 2. Means (Jan. 2007-Nov. 2008) of abundance (A) (ind./m²), Shannon-Wiener diversity index (*H'*), Pielou's evenness (*J'*), salinity (S), temperature (T) (°C) in the mangrove arbor (MA) and seaweed (SW), for all 3 sampling sites on Qi'ao I. in the Pearl River estuary. The annual mean temperature in this region is 22.40°C. *according to Lei et al. (2008)

	2007						2008						
	Jan. MA/SW	Mar. MA/SW	May MA/SW	July MA/SW	Sept. MA/SW	Nov. MA/SW	Jan. MA/SW	Mar. MA/SW	May MA/SW	July MA/SW	Sept. MA/SW	Nov. MA/SW	Mean
A	56/40	1104/456	200/164	120/80	728/384	324/208	168/124	1432/488	176/136	136/108	256/184	400/232	216
H'	0/0.72	0.07/0.27	0.28/0.56	0.77/0	0/1.66	0.35/1.75	0/2.05	0/2.19	0.70/2.77	0.67/1.43	0.60/0	0/0	0.47
J'	0/0.72	0.04/0.14	0.18/0.35	0.38/0	0/0.52	0.18/0.76	0/0.73	0/0.78	0.44/0.99	0.67/0.55	0.30/0	0/0	0.21
S	12.50	14.67	13.10	10.33	14.67	20.33	21.33	21.67	12.34	14.67	11.33	14.33	15.08
T	14.40	21.10	29.20	31.80	26.90	16.20	15.30	21.90	30.00	30.90	27.80	17.30	22.40*

2000a b).

Differences in the abundances in the MA and SW during the sampling period were significant and exhibited the same trends. Most specimens were found in Mar., with the fewest specimens recorded in Jan. and July. The significant difference in abundances was most likely attributable to significant fluctuations in air temperatures. The lowest air temperature was 3°C in winter, and the highest temperature can reach 38°C in summer in

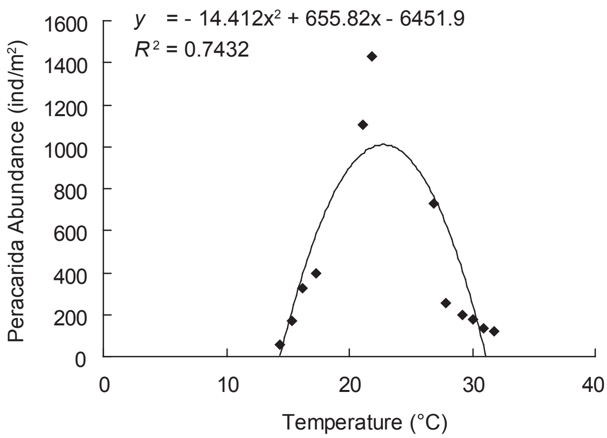

Fig. 4. Variations in Peracarida abundances with temperature in the mangrove arbor on Qi'ao I. in the Pearl River estuary.

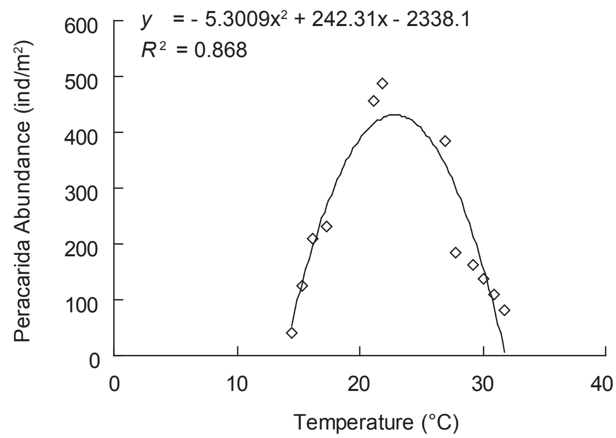

Fig. 5. Variations in Peracarida abundances with temperature in seaweed on Qi'ao I. in the Pearl River estuary.

Table 3. List of Peracarida species sampled and identified in the mangrove arbor (MA) and seaweed (SW) from Jan. 2007 to Nov. 2008 on Qi'ao I. in the Pearl River estuary

Taxa/data	2007						2008					
	Jan.	Mar.	May	July	Sept.	Nov.	Jan.	Mar.	May	July	Sept.	Nov.
	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW	MA/SW
Class Crustacea												
Subclass Malacostraca												
Superorder Peracarida												
Order Amphipoda												
Family corophiidae Leach, 1814												
Corophium insidiosum Crawford, 1937		1/1	1/2	2/0	0/4		0/12	0/48	2/2	0/1	2/0	
Corophium sinensis Zhang, 1974		1/1	0/2	1/0	0/2	1/1	0/1	0/9	0/4	0/1	2/0	
Grandidierella japonica Stephensen, 1938					0/2			0/5	0/2			
Grandidierella gilesi Chilton, 1921								0/2	0/1			
Family Melitidae Bousfield, 1977												
Eriopisa chilkensis (Chilton, 1921)			1/0	1/0	0/2	2/2	0/1	0/6	4/4	6/1	2/0	
Melita longidactyla Hirayama, 1987						1/3	0/2	0/14	0/2			
Melita latiflagella Ren, 2006					0/3		0/1					
Melita sp.					0/2	0/2	0/1		0/5	0/1		
Family Paracalliopiidae Barnard and Karaman, 1982												
Paracalliope sp.		0/2			0/3				0/2			
Order Isopoda												
Paranthuridae Menzies and Glynn, 1968												
Paranthura japonica Richardson, 1909	0/2				0/10					0/4		
Order Tanaidacea												
Parapseudidae Gutu, 1981												
Discapseudes mackiei Bamber, 1997	14/8	274/110	48/37	26/20	182/68	78/24	42/8	358/38	38/12	28/20	58/46	100/58

the Pearl River estuary (Lei et al. 2008).

Shannon-Wiener's index and Pielou's evenness of the Peracarida on Qi'ao I. in the Pearl River estuary did not show clear trends. Mean values were lower than ports of the northwestern Aegean Sea (Chintiroglou 2004) and subtidal sediments from the Ría de Aldán, Spain (Lourido et al. 2008). The assemblages in most periods of the MA and SW were dominated by a few species (especially Tanaidaceans), and no Peracarida in most periods in the EP, resulting in low biodiversity.

Different results of investigations in different areas may be a result of non-standardized sampling methods, sampling sizes, habitat types, and sampling gear (Brandt 1997). Moreover, most previous studies focused on spatial discrepancies, not seasonal or temporal discrepancies (e.g., Brandt 1993, Brandt et al. 1997, Lourido et al. 2008). For these reasons, an exact comparison between the peracarid fauna of Qi'ao I. and other studies is difficult.

Differences in species composition, richness, and diversity of the Peracarida under different vegetation types can be attributed to many factors (e.g., hydrodynamism, sedimentation, carbonates, and microhabitats), either alone or in combination with other factors (Virginia 2000). This study tried to control the physicochemical discrepancy of the environments among sampling sites by selecting sites in close proximity to one another. There were significant discrepancies in the Peracarida composition, abundance, and diversity in the different vegetation types on Qi'ao I. in the Pearl River estuary. The highest diversity was recorded in the SW and the lowest in the EP. One possible reason for this was sediments. Different sediments significantly impact the zoobenthic composition (e.g., Brandt 1993, Fefilova et al. 2008). Generally, the Peracarida prefers soft to hard bottoms (Chintiroglou et al. 2004). In the EP, the sediment was a hard bottom, while those of the MA and SW were soft bottoms.

In the present research, the Amphipoda seemed more adapted to the SW than the MA. SW is characterized by many microhabitats and ecological niches; it also stabilizes sediments and provides living space and shelter (Edgar et al. 1994, Jernakoff et al. 1996). Many amphipod species are euryphagic and are able to take advantage of these different microhabitats (Dauby et al. 2001, Chintiroglou et al. 2004).

Tanaidaceans showed low diversity but a high number of individuals in shallow water (Kneib 1992). Tanaidaceans often exceed 10^4 ind./m^2, and the record was 1.4×10^5 ind./m^2 in shallow water (Błażewicz-Paszkowycz and Jazdzewski 1996). In the Pearl River estuary, the distribution of Tanaidaceans was limited to small areas, and only a few species were recorded (Bamber 1997).

Most tanaids are considered to be non-selective deposit-feeders (Dennell 1937, Mendoza 1982); higher abundances were sampled in the mangrove which provides a rich source of leaves litter. *Discapsuedes mackiei* lives in burrows in the sedimentary clay. It appeared in high densities compared to other elements of the macro-zoobenthos in the Pearl River estuary (Huang et al. 2002, Liu et al. 2003). *D. mackiei* density was lowest in winter; in contrast, the density of *Hargeria rapax* (Harger, 1879) was highest in winter (Kneib 1992). One possible reason for this low value for *D. mackiei* was low temperatures in winter. The Qi'ao I. in the Pearl River estuary is located in the transition zone between the subtropics and tropics, and the lowest temperature can reach 3°C in winter (Lei et al. 2008).

Changes in diversity and other community metrics (e.g., abundance, evenness, and species richness) of the Peracarida due to abiotic and biotic factors were variable. Salinity and temperature are considered to be primary decisive factors affecting the community structure in many aquatic systems (Therriault 2002, Yamada et al. 2007). The food supply and sediment composition are other principal factors (Bakanov 2003).

The effect of temperature on Peracarida abundance was significant ($p < 0.01$, *F*-test), and the optimum temperature was 22-23°C in both the MA and SW; this value is in accordance with the annual mean temperature (22.4°C) of the investigated region (Lei et al. 2008). The salinity in the Mangrove Nature Reserve on Qi'ao I. is primarily affected by rainfall as Qi'ao I. is close to land (about 1.5 km) and the mouth of the Pearl River (about 10 km downstream). In general, the mean value was low in summer and high in winter.

In conclusion, mangrove arbor and seaweed were good for protecting the biodiversity of the Peracarida; in contrast, emergent plants showed little importance for supporting either abundance or diversity. This study proves that temperature is one of the primary decisive factors for the Peracarida community in aquatic systems.

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