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Spatial and temporal variations of mesozooplankton in the Pearl River estuary, China

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Abstract

This paper examines spatial and temporal variations of mesozooplankton abundance, biomass and community structure during three cruises of July 2002 (summer), January 2003 (winter), and April 2003 (spring) in the Pearl River estuary, China. Zooplankton abundance and biomass fluctuated widely and showed distinct heterogeneity in the Pearl River estuary. A total of 154 species were identified during three surveys. The number of zooplankton species richness was strongly linked to salinity. Hierarchical cluster analysis identified three zooplankton groups during this study. Estuarine, neritic and pelagic groups corresponded to the upper, middle and lower reaches in the Pearl River estuary. The difference among groups could be mainly ascribed to changes in the relative contributions of the dominant species. The fluctuations in the zooplankton abundance, biomass and community structure were determined by the interactive effects of freshwater inflow, tidal and coastal currents, chlorophyll *a*, salinity and temperature. Significant spatial variability in the distribution of zooplankton species, abundance and biomass can be ascribed to the virtual presence of a horizontal gradient in salinity.

Keywords: zooplankton; abundance; biomass; community structure; Pearl River estuary; China

1. Introduction

Most of the estuaries can be classified as two types: temporarily open/closed system and permanently open system according to their topography, mouth status, catchment area and freshwater inflow (Grange and Allanson, 1995; Perissinotto et al., 2000; Froneman, 2001, 2002, 2004). The difference between the temporarily open/closed estuary and the permanently open estuary is that the latter is characterised by a horizontal gradient in salinity and temperature resulted from plentiful freshwater influx (Perissinotto et al., 2000; Froneman, 2002; Mouny and Dauvin, 2002; Telesh, 2004). The importance of horizontal gradients in salinity and temperature in determining the distribution of estuarine organisms is now well documented (Kibirige and Perissinotto, 2003; Froneman, 2004). In estuaries, spatial and temporal variations of zooplankton are driven by environmental factors, food availability, random events, and generally by the interaction of these factors (Li et al., 2000; Froneman, 2001, 2004; Kibirige and Perissinotto, 2003; Vieira et al., 2003; Telesh, 2004). Salinity is a crucial factor controlling spatial and vertical distribution of zooplankton (Morgan et al., 1997; Mouny and Dauvin, 2002; Kibirige and Perissinotto, 2003; Telesh, 2004). In general, polyhaline and mesohaline species are located in the outer part of the estuary, while more oligohaline species occur in the inner part of the estuary (Mouny and Dauvin, 2002; Kibirige and Perissinotto, 2003; Vieira et al., 2003; Abramova and Tuschling, 2005). Water temperature and active

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chlorophyll *a*, together with salinity in the water column influence the seasonal occurrence and spatial quantity of zooplankton in most estuaries (Ambler et al., 1985; Rubens, 1994; Gaughan and Potter, 1995; Froneman, 2001, 2004).

The Pearl River estuary is a large subtropical and permanently open estuary with high productivity. In recent years, rapid economic growth and anthropogenic stress from ambient cities such as Guangzhou, Hong Kong, Macau, Shenzhen and Zhuhai have greatly affected the environment of this estuary. Water-related environmental quality is in bad condition resulted from a great deal of waste, excessive reclamation, over fishing and frequent oil spills there (Lin and Han, 2001; Chen et al., 2004). The Pearl River estuary is an important feeding and spawning ground for many commercial fishes and shrimps. Zooplankton is an important link between phytoplankton and upper tropical levels. However, little information is known on zooplankton variations in such an estuarine environment. Most of previous studies have limited spatial or temporal coverage (Wong et al., 1991; Zhang, 1993; Yin et al., 1995; Tan et al., 2004).

This paper examines the spatial and temporal variability in abundance and biomass, community structure of mesozooplankton in broad areas of the Pearl River estuary, and discusses how environmental factors impact on the distribution of mesozooplankton.

2. Materials and methods

2.1. Study area

The Pearl River estuary is situated on the southern coast of China (21°30′–22°49′N, 113°30′–114°30′E) and its shape is like an inverted funnel with the arrow neck in the north and wide mouth opening to the south (Lin and Liang, 1996). The Pearl River flows into South China Sea through eight distributaries, eastern four (Humen, Jiaomen, Hongqimen and Hengmen) of which enter the Lingdingyang Bay, the upper reaches of the Pearl River estuary. The western outlets are namely Modaomen, Jitimen, Hutiaomen and Yamen (Zhao, 1990). The annual average river discharge is 10,524 $m^3\,s^{-1}$, and varies seasonally reaching a peak of 22,200 $m^3\,s^{-1}$ in summer and about 3988 $m^3\,s^{-1}$ in winter (Huang et al., 2003). About 80% of the total flow occurs in the wet season from April to September, with 20% in the dry season from October to March. A wet and warm southwest monsoon prevails in the wet season, while a dry and cold northeast monsoon predominates during the dry season (Zhao, 1990; Huang et al., 2003; Yin et al., 2004b). The Pearl River estuary is a microtidal one with an average tidal range of 0.9–1.7 m (Mao et al., 2004). The water depth varies from 5 to 20 m in Lingdingyang Bay, and was above 80 m in the lower reaches of the estuary.

2.2. Sampling

Three surveys were conducted at 19 stations in July 2002 (summer), 17 in January 2003 (winter), and 15 in April 2003 (spring) in the Pearl River estuary (Figs. 1 and 3).

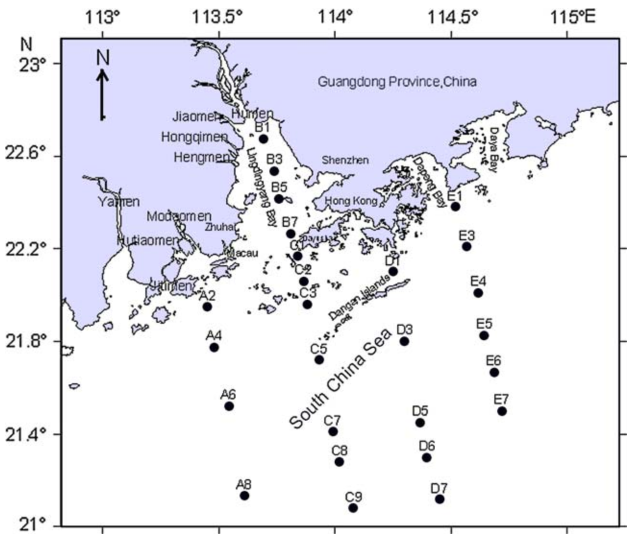

Fig. 1. Sampling stations in the Pearl River estuary.

Zooplankton was sampled using a modified WP-2 net (mouth size, 0.5 m^2; mesh size, 505 μm) by towing vertically from 1 m above the bottom to the surface with the towing speed range between 1.5 and 3 knots (Xu and Chen, 1989; Zhang, 1993; Fu et al, 1995). The base of net was equipped with a heavy hammer (20–40 kg). The filtered water volume was determined by the rope length multiplying mouth size (Xu and Chen, 1989; Zhang, 1993; Fu et al., 1995). The samples collected were preserved immediately in 5% formaldehyde. Salinity and temperature were measured using YSI 6600 Water Quality System. Water samples were collected by 5-L Niskin bottle at different depths for measuring chlorophyll *a*.

2.3. Laboratory procedures

Zooplankton wet weight was measured using an electronic balance after removing large detrital particles and jellyfishes under a dissecting microscope, and eliminating excess and interstitial water by the vacuum extraction technique (Harris et al., 2000). Organisms were identified to species level when possible and counted (Chen and Zhang, 1965; Chen et al., 1974; Chen and Zhang, 1974; Chen and Shen, 1974; Chen, 1983; Zheng et al., 1984). Sub-samples for identification and enumeration were at least 10% of the total samples. For the determination of total chlorophyll *a* concentration, a 250-ml sub-sample was gently filtered through a 0.45-μm cellulose filter and extracted in 90% acetone for 24 h in the dark. Chl *a* concentration was then determined fluorometrically (Turner designs 10 AU fluorometer) before and after acidification (Parsons et al., 1984). Zooplankton abundance and wet weight biomass were expressed as individual m^{-3} and mg ww m^{-3}, respectively.

2.4. Data analysis

The hierarchical cluster and multidimensional scaling (MDS) analyses of similarity between stations during three