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ORIGINAL ARTICLE

Spatial distribution of crustacean zooplankton in a large river-connected lake related to trophic status and fish

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ABSTRACT

It has been reported that community structure of crustacean zooplankton is related to environment factors and abundance of predacious fishes. Most studies, however were based on observation on independent water bodies, which may complicate the results with uninterested factors. A large river-connected lake has partitioned regions with the characteristics of either a river or a lake albeit allowing exchanging of zooplankton of different regions. Thus, a river-connected lake is an ideal system for studying distribution of crustacean zooplankton and investigating its affecting factors. In this study, 11 stations of a large river-connected lake, Lake Gaoyou, were sampled in all four seasons. Taxonomic diversity and species abundance were recorded and their correlation with environmental factors was investigated. A total of 26 and 22 species of crustacean zooplankton were recorded in the river and lake region, respectively. The abundance of crustacean in the river region was significantly higher than that in the lake region. The relative abundance of calanoids and *Bosmina fatalis* in the river region was lower than that in the lake region, whereas the abundance of cyclopoids and other cladocera species was lower in the lake region than in the river region. Cluster analysis showed that crustacean assemblages could be divided into two, one cluster grouping all sites from the river region, and the other cluster included all sites in the lake region. According to Pearson correlation and canonical correspondence analysis, the distribution of crustacean was positively correlated with water temperature and chlorophyll a gradient. Chlorophyll a and fish abundance are excellent predictors on spatial distribution of crustacean zooplankton in Lake Gaoyou. Our findings may also help in planning of bighead carp stocking in Lake Gaoyou.

Key words: River-connected lake; crustacean zooplankton; trophic status; fish.

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INTRODUCTION

Aquatic ecosystems are characterized by complex interactions of biotic and abiotic factors (Fisher *et al.*, 2007). Crustacean zooplankton which comprise cladocerans and copepods are one of the most important organisms, because they occupy an intermediate position between microorganisms (microalgae, rotifers, protozoa, and bacteria) and larger organisms (*e.g.*, fish) (Berggren *et al.*, 2014; Sarma *et al.*, 2006). Meanwhile, because crustacean zooplankton often have wide geographical distributions, sensitive to individual stressors, and their morphology are easy to identify (Cairns *et al.*, 1993), factors affecting community structure of crustacean zooplankton have been studied intensively in the last few years. However, most studies were focused on isolated lakes, reservoirs or on the comparison between different water bodies (Degefu and Schagerl, 2015; Pinto-Coelho *et al.*, 2005), so the results may be complicated by other uninterested factors, such as existing species and community structure due to historic reasons.

A river-connected lake, which is usually connected to a river in the upper and lower reaches, undertakes the flood-drainage task with the migration of water exchange and water-level-fluctuation range. A large river-connected lake, which includes river and lake region, *i.e.*, has the characteristics of the river and lake and presents the rich variety of environmental condition. An important function of a river-connected lake is to repair the ecological environment (Ren *et al.*, 2007). Some researchers have carried out a series studies about the water-environment carrying-capacity calculation methods of river-connected lakes (Wang *et al.*, 2015; Yang *et al.*, 2015). Other researchers focused on the cyanobacteria distribution and macrozoobenthic community in river-connected lakes (Liu *et al.*, 2016; Wang *et al.*, 2007). However, little attention has been paid to the spatial distribution of crustacean zooplankton and their correlation with environmental factors in river-connected lakes. River-connected lakes are ideal system for studying spatial distribution, community structure of crustacean zooplankton and its affecting factors. Different from independent lakes, the zooplankton communities in a river-connected lake are connected, so the difference in community structure of crustacean zooplankton must be due to difference in microhabitat only. Studies on spatial distribution of crustacean zooplankton and the effects of environment factors on crustacean zooplankton communities in river-connected lakes have great significance in the protection and utilization of the water environment. For example, stocking of filter-feeding bighead carp is often planned based on the distribution data of crustacean zooplankton (Guo *et al.*, 2015).

The factors taken into account were mainly water chemistry, macrophytes and eutrophication (Alexander and Hotchkiss, 2010; Dodson *et al.*, 2005). However, the spatial distribution of crustacean zooplankton is not always related to single environmental factor, and have seemingly contradictory distribution patterns in different water bodies (Hulot *et al.*, 2000). Abundance of fishes also is often claimed to be related to the community structure of crustacean zooplankton (Dzialowski *et al.*, 2013), but few studies really reported empirical data on it due to high expense in collecting all fish in experiment regions.

The middle and lower reaches of the Yangtze River are connected by many rivers and lakes that frequently interact with one another. In present study, Lake Gaoyou including river and lake region, as a typical river-connected lake, was sampled to determine the relationships between abundance and structure of crustacean and environmental factors. The objectives are i) to compare zooplankton species composition between the river and lake region, and ii) to investigate the environmental factors influencing on the abundance and structure of the crustacean zooplankton assemblage in the river region and the lake region of the same lake.

METHODS

Study area

Lake Gaoyou (32°42′-33°04′ N, 119°06′-119°25′ E) is the sixth largest freshwater lake in China and covers an area of 674.7 km^2, with a mean depth of 1.44 m and a maximum depth of 2.4 m. It lies in central Jiangsu Province, lower reaches of the Huaihe River and west of the Jing-Hang (Beijing-Hangzhou) Grand Canal with subtropical and monsoon climate (Liu *et al.*, 2016). Water from the Huaihe River contributes 95% of the total input for the south of Lake Gaoyou *via* the waterway to the Yangtze River (Li *et al.*, 2007). The river region exists in the south part of Lake Gaoyou and the lake region exists in the north (Fig. 1A). In July, the dominant macrophyte species in the river region is *Myriophyllum spicatum* (wet weight biomass, 0.4 kg/m^2). The dominant macrophyte species in the lake region is *Trapa incisa* (wet weight biomass, 6.2 kg/m^2). Water in river region often is turbid, whereas water in lake region is clear. Another character distinguishing the river region and the lake region is the sediment. The river region has a hard bottom, whereas the lake region has deep soft sediment.

Sampling and physicochemical analyses

Eleven sampling stations were selected at regular spatial intervals from south to north. The river region included the stations s1, s2, s3, s4, s5, s6 and the lake region

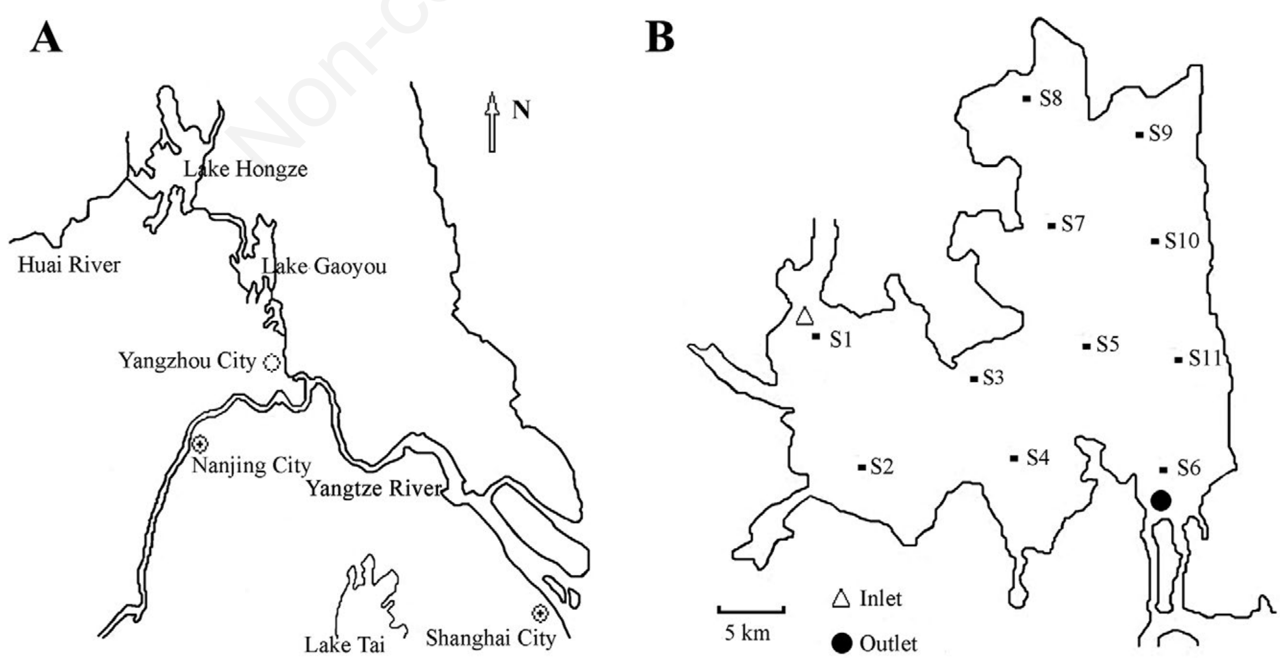

Fig. 1. Maps of (A) location of Lake Gaoyou and (B) 11 sampling stations in the lake.

included the stations s7, s8, s9, s10, s11 (Fig. 1B). Samples were collected on four seasons: April, July, October in 2013, and January in 2014. Physical-chemical parameters including water temperature (WT), transparency (Secchi disk depth), dissolved oxygen (DO), and pH were determined *in situ* below the water surface (0.5 m). WT and DO were measured using FG4-FK (Mettler Toledo Co., Greifensee, Switzerland), and pH was measured using FG2-FK (Mettler Toledo Co.). Water samples below the water surface (0.5 m) were collected in plastic bottles to measure total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* (Chl *a*; pretreated with 1% $MgCO_3$) according to the Chinese Standard Methods for the Surveys of lake eutrophication (Jin and Tu, 1990) .

Crustacean and fish analysis

For each station, 50 L of water was collected at a depth of 0.5 m using bucket hauls, and the crustacean sampled was filtered through a plankton net (mesh size: 0.064 mm) and preserved in 4% (final concentration) formalin solution. zooplanktonic crustacean were identified based on their morphology (Chiang and Du 1979) and then counted at 40× magnification with an Olympus CX21 microscope. Cladoceran and copepod adults were only considered in this study.

To investigate the fish abundance, water area up to 10.0 ha^2 was respectively enclosed with polyethylene mesh (3.0 cm) in the river and lake region in December 2013, and four electronic trawl nets (Direct Current Voltage, 380V, 12A) were trawled simultaneously for 2 hour in the enclosures to capture as many fish as we can.

Data analysis

An independent-samples t-test was used to compare the difference of physical-chemical parameters and crustacean abundance between the river and lake region using SPSS ver. 15.0 software. The degree of similarity of crustacean zooplankton assemblages among the 11 sites was calculated using the Bray-Curtis similarity coefficient and Ward's method based on the abundance of each species in PCORD (Nanami *et al.*, 2005). Pearson's Correlation Analysis was used to determine the relationships between zooplankton abundance and the environmental variables using SPSS ver. 15.0 software. Additionally, these relationships were confirmed with a canonical analysis, which combines the concepts of ordination and regression using CANOCO 4.5 (ter-Braak and Šmilauer, 2002).

RESULTS

Physicochemical parameters

The mean ± SD values of the physical and chemical composition, and P-values for *t*-tests between the river and lake region were listed in Tab. 1. The WT, DO, pH, or TP determined was not significantly different between the river and lake region (P>0.05). However, significant difference was detected for TN (P<0.05), transparency and Chl a (P<0.01) (Tab. 1).

Comparison of fish

In river region, the three main species were *Carassius auratus*, *Cultrichthys erythropterus* and *Erythroculter ilishaeformis*, but *C. auratus*, *C. erythropterus* and *Hemiculter leucisculus* were the three dominant species in lake region. The fish abundance and total mass of the river region were lower than that of the lake region (Tab. 2).

Species composition and occurrence frequency of crustacean

In the river region, a total of 26 species of crustacean zooplankton were collected, including 14 species of cladocera (53.85% of abundance; belonging to 10 genera) and 5 species of *calanoida* (19.23%; belonging to 4 genera) as well as 7 species of *cyclopoida* (26.92%; belonging to 7 genera); and 10 species (*D. leuchtenbergianum*, *B. fatalis*, *Bosminopsis deitersi*, *Moina micrura*, *Sinocalanus*

Tab. 1. Mean ± SD values for the physical and chemical composition, and P values for *t*-tests between river region and lake region (95% confidence interval).

	River region	Lake region	P value
Water temperature (°C)	18.88±8.87	18.86±9.11	0.995
Dissolved oxygen (mg L^{-1})	8.01±1.66	8.64±2.42	0.334
pH	7.81±0.42	8.03±0.92	0.305
Transparency (m)	0.38±0.27	0.77±0.42	0.001
Total nitrogen (mg L^{-1})	0.99±0.49	0.74±0.23	0.043
Total phosphorus (mg L^{-1})	0.10±0.06	0.08±0.04	0.097
Chl *a* (ug L^{-1})	1.73±1.02	0.87±0.51	0.001

In river region cases n = 6 station sites× 4 seasons; in lake region cases n=5 station sites× 4 seasons.

dorrii, *Schmackeria forbesi*, *Heterocope appendiculata*, *Limnoithona sinensis*, *Mesocyclops leuckarti*, *Thermocyclops taihokuensis*) were present in all six sites. In the lake region, a total of 22 species of crustacean zooplankton were collected, including 10 species of cladocera (38.46%; belonging to 9 genera) and 5 species of *calanoida* (22.73%; belonging to 4 genera) as well as 7 species of *cyclopoida* (31.82%; belonging to 7 genera); and 6 species (*B. fatalis*, *B. deitersi*, *S. dorrii*, *H. appendiculata*, *P. fimbriatus*, *T. taihokuensis*) appeared in all five sites (Tab. 3).

Abundance and relative abundance of crustacean

The abundance of cladocerans, calanoids, cyclopoids and total crustacean in the river region were higher than those in the lake region, and the cladocerans, cyclopoids and total crustacean showed significant difference between the river and lake regions ($P<0.05$) (Fig. 2). The relative abundance for *B. fatalis* and calanoids in the river region (53.22% and 6.83%) was lower than that of the lake region (62.40% and 9.33%), but the relative abundance for other cladocera and cyclopoids in the river region (24.10% and 16.70%) was higher than that in the lake region (4.55% and 12.25%), respectively (Fig. 3).

Cluster analysis

Cluster analysis revealed that crustacean assemblages could be divided into two groups. Cluster A consisted of six sites mainly located on the southern side, *i.e.*, the river region of Lake Gaoyou. Cluster B consisted of five other sites located on the northern side, *i.e.*, the lake region of Lake Gaoyou (Fig. 4).

Correlation analysis

Correlation analysis indicated that cladoceran, calanoid, cyclopoid and crustacean abundance was positively correlated with WT and Chl *a*, and negatively correlated with DO. Meanwhile, cladoceran, calanoid and crustacean abundance were positively correlated with TN (Tab. 4).

Redundancy analysis

Detrended correspondence analyses (DCA) of the species data indicated that the first gradient length was

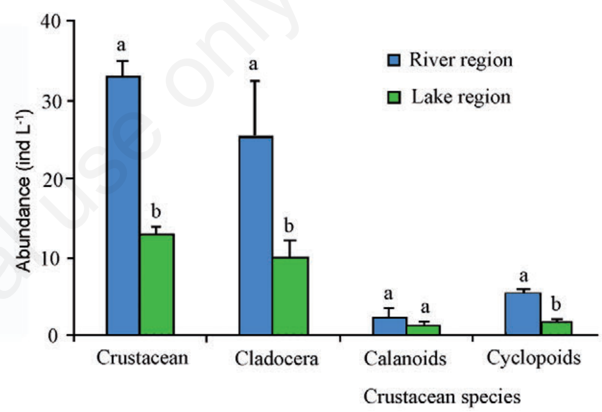

Fig. 2. The crustacean abundance of the river and lake region in Lake Gaoyou. In river region cases n=6 station sites×4 seasons; in lake region cases n=5 station sites×4 seasons; a and b means $P<0.05$, whereas a and a means $P>0.05$.

Tab. 2. The species of fishes in Lake and River region.

	River region (ha⁻¹)		Lake region (ha⁻¹)	
	Abundance (ind)	Yield (kg)	Abundance (ind)	Yield (kg)
Carassius auratus	2058.6	50.4	4852.8	97.0
Cultrichthys erythropterus	960.9	9.0	3421.4	48.1
Erythroculter ilishaeformis	147.6	8.4	136.2	10.9
Pseudorasbora parva	53.1	3.1	126.8	0.7
Channa argus	46.5	17.7	70.3	20.5
Hemiculter leucisculus	41.4	1.0	2472.0	14.2
Cyprinus carpio	23.4	29.9	18.0	29.3
Acheilognathus macropterus	10.4	0.05	-	-
Pelteobagrus fulvidraco	7.5	0.4	-	-
Coilia nasus	1.2	0.05	-	-
Protosalanx hyalocranius	1.2	0.03	-	-
Hyporhamphus intermedius	51.6	0.2	-	-
Total	3403.7	121.3	11097.4	220.7

relatively short (2.406), and thus linear-ordination methods were as appropriate as redundancy analysis (RDA). RDA was performed on the whole environmental and species datasets. Results showed that the eigenvalues for RDA axes 1(0.337) and 2(0.014) account for 35.1% of the variance in the species. Forward selection and Monte Carlo simulations indicated that 2 environmental factors (WT and Chl *a*) out of the total 7 variables made independent and significant contributions to the variance in abundance of the crustacean assemblages (P<0.01). Variability in species data was explained by WT (33.80%), Chl *a* (23.94%) (Tab. 5). All crustacean zooplankton were positively correlated with WT, Chl *a* gradient (Tab. 5 and Fig. 5).

DISCUSSION

The difference of physicochemical parameters was influenced by macrophytes and hydrodynamic conditions. Macrophytes can significantly enhance water residence time, and nitrogen and phosphorus were retained by increasing deposition of particulate organic matter (Schulz *et al.*, 2003). Allelochemicals released by submerged macrophytes can also inhibit growth of phytoplankton and contribute to the stabilisation of clear-water states in shallow lakes (Hilta and Gross, 2008). Our results are consistent with previous studies that TN and TP in the lake

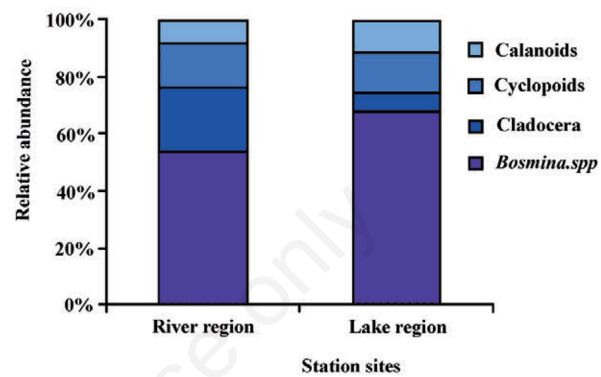

Fig. 3. The relative abundance of crustacean in the river and lake regions in Lake Gaoyou.

Tab. 3. Composition, distribution and occurrence frequency of crustacean zooplankton in Lake Gaoyou.

Code	Species	River region		Lake region	
		Emerged station	Occurrence frequency (%)	Emerged station	Occurrence frequency (%)
	Cladocera				
1	*Diaphanosoma brachyurum*	s1;s2;s4;s5;s6	83.3	s10;s11	40.0
2	*D.leuchtenbergianum*	s1;s2;s3;s4;s5;s6	100.0	s10	20.0
3	*Chydorus ovalis*	s2;s3;s4;	50.0	s8	20.0
4	*Alona quadrangularis*	s1;s3	33.3	s8;s10	40.0
5	*Bosmina.fatalis*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s9;s10;s11	100.0
6	*Bosminopsis deitersi*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s9;s10;s11	100.0
7	*Scapholeberis mucronata*	s3;s4	33.3	s7;s8;s9;s10	80.0
8	*Daphnia psittacea*	s3;s6	33.3	-	0
9	*D.cucullata*	s2;s3;s4;s5;s6	83.3	s9	20.0
10	*Simocephlaus vetulus*	s1;s2;s3;s4	66.7	s7	20.0
11	*Ceriodaphnia cornuta*	s2;s3;s4;s5;s6	83.3	s7	20.0
12	*C.quadrangula*	s1;s3	33.3	-	0
13	*Moina micrura*	s1;s2;s3;s4;s5;s6	100.0	-	0
14	*M. macrocopa*	s1;s2;s3;s6	66.7	-	0
	Calanoida				
15	*Sinocalanus dorrii*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s9;s10;s11	100.0
16	*Schmackeria inopinus*	s1;s3;s4;s5;s6	83.3	s7	20.0
17	*Schmackeria forbesi*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s10;s11	80.0
18	*Heterocope appendiculata*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s9;s10;s11	100.0
19	*Neutrodiaptomus incongruens*	s3;s4;s5;s6	66.7	s7;s10	40.0
	Cyclopoida				
20	*Limnoithona sinensis*	s1;s2;s3;s4;s5;s6	100.0	s10;s11	40.0
21	*Tropocyclops prasinus*	s2;s3	33.3	s8	20.0
22	*Paracyclops fimbriatus*	s1;s2;s3;s4;s5	83.3	s7;s8;s9;s10;s11	100.0
23	*Cyclops vicinus*	s3	16.7	s8	20.0
24	*Mesocyclops leuckarti*	s1;s2;s3;s4;s5;s6	100.0	s7;s10;s11	60.0
25	*Thermocyclops taihokuensis*	s1;s2;s3;s4;s5;s6	100.0	s7;s8;s9;s10;s11	100.0
26	*Microcyclops varicans*	s4;s5;s6	50.0	s8	20.0

region were lower than that of the river region, but water transparency had an opposite pattern. Hydrodynamic conditions are important factors for planktonic algae growth. The algae abundance under weak water flow was usually higher, and 0.04 ms^{-1} or so was considered to be the optimal velocity for algae growth because water movement brings new resource for propagation and growth of algae (Hilton *et al.*, 2006; Long *et al.*, 2011). Water from the Huai river flows from the river region of Lake Gaoyou, the velocity was lower than 0.02 ms^{-1} (Zhang and Zhou, 2009), which may lead to higher phytoplankton abundance, *e.g.*, higher Chl *a* concentration in the river region than the lake region.

Transparency and Chl *a* concentration have become the best measure of trophic status (Carlson, 1977), because transparency can provide an estimator of the volume of the phytoplankton biomass (Wu *et al.*, 2015) and Chl *a* can measure algal abundance (Rosa and Michelle, 2007). Total nitrogen (N) was also the one of index "trophic status", because nitrogen (N), needed for protein synthesis, was important nutritional element to satisfy phytoplankton growth and was the key limiting nutrients in most aquatic waterbodies (Conley *et al.*, 2009). The lower transparency and higher Chl *a* and TN showed trophic status in the river region was higher than that in the lake region (Tab. 1).

In general, fish assemblages in most subtropical lakes are dominated by small omnivorous fish and zooplanktivory is high (Kruk *et al.*, 2009; Lazzaro, 1997). Fishes in lake Gaoyou mainly composed of *C. auratus*, *C. erythropterus and H. leucisculus* with average weight of 0.021 kg ind^{-1}, 0.013 kg ind^{-1} and 0.006 kg ind^{-1}. Aquatic plants play a vital role in affecting the spatial distribution of aquatic organisms and shaping predator-prey interactions in shallow lakes (Meerhoff *et al.*, 2007). Zooplanktivorous fish aggregate among aquatic plants that offer shelter against piscivorous fish and birds (González-Sagrario and Balseiro, 2010). In Lake Gaoyou, only sporadic *M. spicatum* interspersed in the river region, but *T. incisa* paved in the lake region. The relatively difference of fish abundance species and yields existed between the river and lake region, *C. auratus*, *C. erythropterus* and *E. ilishaeformis* were the three dominant species in the river region with abundance of 2058.6 ind ha^{-1}, 960.9 ind ha^{-1} and 147.6 ind ha^{-1}, but the three dominant species in the lake region was *C. auratus*, *C. erythropterus* and *H. leucisculus* with abundance of 4852.8 ind ha^{-1}, 3421.4 ind ha^{-1} and 2472.0 ind ha^{-1}.

From Pearson's Correlation Analysis and canonical analysis, the distribution of crustacean zooplankton in the Lake Gaoyou were positively correlated with WT and Chl *a* gradient. Temperature is recognized as an important structuring factor for the crustacean zooplankton composition in natural lakes because temperature controls feeding, respiration, egg production rates and other metabolic processes (Moore *et al.*, 1996) . The crustacean abundance in the river region was higher than one of the lake region (P<0.05). Many previous studies indicated most nutrient-enriched waterbodies were characteristic of an increase

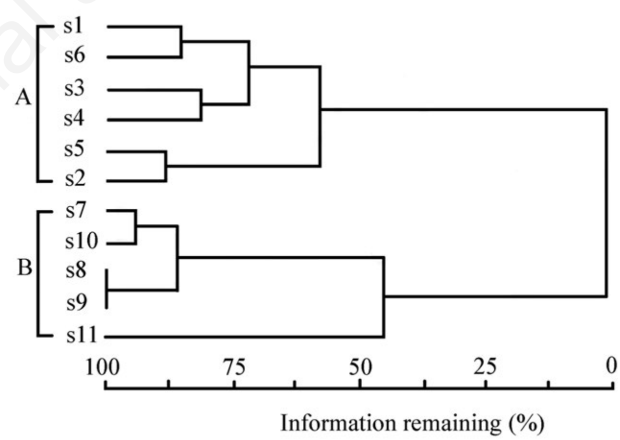

Fig. 4. Hierarchical cluster analysis of crustacean at 11 sampling points in Lake Gaoyou (group-average linkage method using Bray-Curtis similarities). The location for each station refers to Fig. 1B.

Tab. 4. Values for Pearson's correlations of zooplankton abundance and physiochemical parameters.

	Cladoceran	Calanoid	Cyclopoid	Crustaceran
Water temperature	0.554**	0.429**	0.619**	0.606**
Dissolved oxygen	-0.449**	-.446**	-.386*	-.472**
pH	-0.001	-0.034	-0.2	-0.049
Transparency	-0.238	-0.196	-0.158	-0.237
Total nitrogen	0.377*	0.318*	0.23	0.371*
Total phosphorus	0.023	-0.04	0.025	0.021
Chl *a*	0.496**	0.532**	0.479**	0.537**

**P<0.05; **P<0.01.*

of primary production as zooplankton populations relied on phytoplankton as a food source, which resulted in an increase of zooplankton abundance (Hulyal and Kaliwal, 2008; Larson *et al.*, 2006).

Meanwhile, the crustacean zooplankton structure did change with the changes of trophic status over the waterbodies. In our study, the relative abundance for cyclopoids and cladocera in the river region was higher than that in the lake region respectively, and the relative abundance for calanoids and *B. fatalis* in the river region were lower than that in the lake region (Fig. 3). In general, calanoida (principally herbivorous-filter feeding habit of most species), occur mainly in more oligotrophic waterbodies, where there is a predominance of nanophytoplankton, whereas the cyclopoida occurs at higher abundance under more eutrophic status, owing to their ability to grip larger food particles and prey on smaller species of rotifera and cladocera (Pace, 1986; Santos-Wisniewski and Rocha, 2007).

The eigenvalues for RDA axes express only 35.1% of the variance of crustacean, the fish can also effect the distribution of crustacean community. The abundance of zooplankton is largely determined by predation pressure, because they are available food of zooplanktivorous fish. It was reported that macrophytes can help zooplankton as refugees escaping from predation by zooplanktivorous fish (Basu *et al.*, 2000). But, aquatic plants are obviously not an efficient daylight refuge for zooplankton, as fish abundance is high among the plants in subtropical lakes (Meerhoff *et al.*, 2007). The result that the abundance of crustacean in the river region were higher than those in the lake region showed aquatic plants had not shelter zooplankton from zooplanktivorous fish. Predation by zooplanktivorous fishes can also be a important factor structuring zooplankton composition. Zooplankton com-

Tab. 5. Environmental variables identified by RDA with forward selection and Monte Carlo permutation tests explaining the significant proportions of variance in crustacean species-environment relationship in Lake Gaoyou.

Variables	Eigenvalues	Variance explained
Water temperature**	0.24	33.80
Chl a**	0.17	23.94
Dissolved oxygen	0.17	23.94
Total nitrogen	0.07	9.86
Transparency	0.03	4.23
pH	0.02	2.82
Total phosphorus	0.01	1.41
Total		100.0

***P<0.01.*

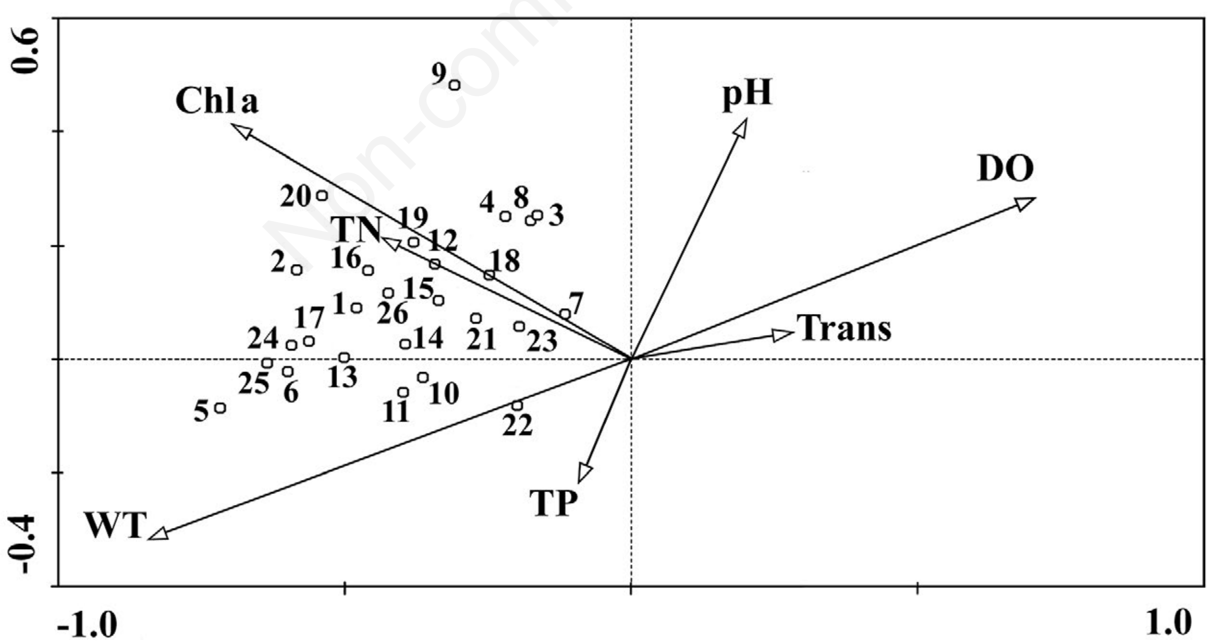

Fig. 5. RDA biplot of crustacean species and environmental variables in Lake Gaoyou. 1, *D. brachyurum*; 2, *D. leuchtenbergianum*; 3, *C. ovalis*; 4, *A. quadrangularis*; 5, *B. fatalis*; 6, *B. deitersi*; 7, *S. mucronata*; 8, *D. psittacea*; 9, *D. cucullata*; 10, *S. vetulus*; 11, *C. cornuta*; 12, *C. quadrangula*; 13, *M. micrura*; 14, *M. macrocopa*; 15, *S. dorrii*; 16, *S. inopinus*; 17, *S. forbesi*; 18, *H. appendiculata*; 19, *N. incongruens*; 20, *L. sinensis*; 21, *T. prasinus*; 22, *P. fimbriatus*; 23, *C. vicinus*; 24, *M. leuckarti*; 25, *T. taihokuensis*; 26, *M. varicans*; WT, water temperature, DO, dissolved oxygen; TP, total phosphorus; TN, total nitrogen.

munities subjected to fish predation are dominated by small bodied species (*e.g.*, *Bosmina*), because zooplanktivorous fishes predate preferentially some cladoceran species (*e.g.*, *Daphnia*) with large-bodied and slowly escape ability. Whereas copepods have been found to be lesser preferred prey than cladocerans, probably owing to faster swimming speeds and greater escape reply (Bourdeau *et al.*, 2015; Kiørboe, 2011).

CONCLUSIONS

Lake Gaoyou, a large river-connected lake, has obvious river and lake region. Higher abundance of crustacean zooplankton, higher relative abundance for cladocera and cyclopoids and lower relative abundance for calanoids in the river region than that in the lake region may attribute to difference in eutrophic status and fish abundance.

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