COMMUNITY STRUCTURE OF PLANKTONIC COPEPODA IN A SHALLOW, MACROPHYTIC LAKE, LAKE BIANDANTANG*

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Abstract Community structure of copepods, including species composition, population dynamics and standing crops, was studied in a shallow, macrophytic lake, Lake Biandantang (Hubei, China). During one year study, 14 species (9 Cyclopoida and 5 Calanoida) were found. In terms of annual average density, the dominant Cyclopoida were *Mesocyclops notius, Cyclops vincinus vincinus* and *Thermocyclops brevifurcatus,* and meanwhile *Neodiaptomus yantsekiangensis* and *Sinocalanus dorrii* dominated the Calanoida. A comparison of species composition of Copepoda in five macrophytic lakes along the Changjiang River shows that the species number of Copepoda is not proportional to the surface area of the lake, which is not Coincident with Dodson's conclusion on the positive relationship of lake surface area vis-à-vis cladocera species number in European and North American Lakes. It was also found that although there were as many as 35 species of planktonic Copepda in these lakes, the dominants were quite similarly limited to a few genus or a few species, while the most other species only appeared incidentally.

Key words Copepoda, Subtropical Chinese lake, species richness, Submerged macrephytes, Ecological studies

Along the middle and lower reaches of the Changjiang River, there are numerous freshwater lakes which constitute ca. 1 / 8 of the total land area of this region. This area is the most important freshwater fishery production base, because its fish yield constitutes about 2 / 3 of the total landing of freshwater fishes in China (Cao, 1992).

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These lakes are shallow (usually less than several meters in depth) and covered with abundant macrophytes on their bottoms, and in this sense, such lake ecosystems are similar to those of littoral zones in deep lakes. These macrophytic shallow lakes are considered to be one of the world's exceptional pool full of hydrobiological taxa (Liang & Liu, 1995). Copepods are one of the major groups of zooplankton in freshwater lakes. In theses shallow lakes, although there were some studies on copepods, but mostly referred to species list. Only a few studies have been done on both species composition and abundance or population dynamics of each copepod species (Chen, 1965). The present study is aimed to clarify species composition, population dynamics, and standing crops of planktonic Copepoda in a macrophytic lake, Lake Biandantang, and to compare species composition of Copepoda in several macrophytic lakes along the Changjiang River.

1 Materials and Methods

Lake Biandantang (Fig. 1), 30° 15'N, 114° 23'E, is on the alluvial plain of the middle basin of the Changjiang River. It is one part of Lake Baoan which was divided into several small lakes by artificial banks decades ago. Lake Baoan is connected with the Changjiang River through a small channel. Lake Biandantan is a small lake with a surface area of 3.3 km^2 and an average depth of 1.90 m. It is a macrophytic lake: the autumn biomass of submerged-macrophytes during 1986 to 1993 was between 143–3130 (average 1673.8) g / m^2, and the coverage rate of submerged macrophytes was as high as 75% of the total lake area; and the dominant species were *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L. (Su et al., 1995). The average chlorophyll a amount and the fresh weight of phytoplankton were 2.36 μg / L and 0.22 mg / L, respectively (Wang & Liang, 1995). Water temperature is between 5—34℃, and the monthly average is above 20℃ during April to October (Zhang & Liu, 1995).

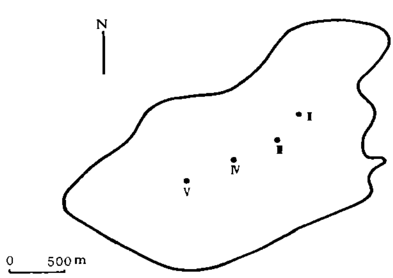

Fig.1 Map of Lake Biandantang

Copepod samples were taken at monthly intervals from four sampling stations across the lake from April 1996 to March 1997. The samples were taken using a 5-L modified Patalas' bottle sampler. Each sample was the mixture of several subsamples collected from the surface to the bottom at 0.5 m intervals, and 25—50 L of the lake water was strained through a 60 μm mesh plankton net. The samples were fixed with 4% formalin. Usually 20—50 individuals of the dominant species were measured in each sample. The volume of copepods (nauplius, copepodid and adult) was estimated by using geometric figures of their approximate shapes (the eggs were not included in the calculation of their biovolume). In converting the volume of copepods to wet weight, the 10% ratio was adopted after considering Schindler & Noven (1971), Dumont et al. (1975), Bottrell et al. (1976) and Lawrence et al. (1987). Copepods were identified according to Shen (1979), Dussart & Fernando (1988), Kiefer (1981), and Xie & Takamura (1997).

2 Results

During the one year study, 14 species (9 Cyclopoida and 5 Calanoida) were found (Tab. 1). In terms of annual average density, the dominant Cyclopoida were *M. notius*, *C. vincinus vincinus* and *T. brevifurcatus*, and meanwhile *N. yantsekiangensis* and *S. dorrii* dominated the Calanoida. Seasonally, *C. vincinus vincinus* and *S. dorrii* dominated in the winter, while *M. notius* domianted in the spring, and a mixture of *N. yantsekiangensis*, *M. notius* and *T. brevifurcatus* dominated in the summer.

Tab. 1 Annual average density (No./ L) of planktonic copepoda (copepodids+adults) at four sampling stations of Lake Biandantang

Species Stations	II	III	IV	V
Cyclopoida				
M. notius, Kiefer, 1981	6.103	4.673	6.327	4.806
C. vincinus vincinus Uljanin, 1875	2.531	3.532	1.770	2.213
Thermocyclops brevifurcatus Harada, 1931	1.399	0.707	1.597	0.451
T. taihokuensis Harada, 1931	0.204	0.589	0.211	0.569
M. varicans (Sars, 1963)	0.248	0.763	0.000	0.173
M. albidus (Jurine, 1820)	0.033	0.000	0.213	0.000
Eucyclops macruroides denticulatus (Graeter, 1903)	0.004	0.000	0.107	0.000
E. phaleratus (Koch, 1838)	0.003	0.000	0.000	0.000
Neoergasilus sp.	0.023	0.003	0.008	0.000
Calanoida				
Neodiaptomus yantsekiangensis Mashiko, 1951	4.480	3.611	2.991	3.116
Sinocalanus dorrii (Brehm, 1909)	1.596	3.852	1.817	1.964
Schmackeria forbesi Poppe et Richard	0.403	0.383	0.653	0.462
Phyllodiaptomus tunguidus Shen et Tai, 1964	0.133	0.123	0.053	0.063
N. schmackeria (Poppe et Richard, 1892)	0.029	0.123	0.082	0.008
Cyclpoida+Calanoida	16.19	18.36	15.83	13.82

Tab. 2 Annual average density (No./L) and biomass (μg wet weight per liter) of planktonic Copepoda at four sampling stations of Lake Biandantang

Stations	Cyclopida Density (Biomass)	Calanoida Density (Biomass)	Nauplius Density (Biomass)	Total Copepoda Density (Biomass)
II	10.55(89.3)	5.64(68.9)	58.38(57.5)	74.57(215.7)
III	10.27(95.9)	8.09(138.4)	61.70(59.8)	80.06(294.0)
IV	10.23(65.9)	5.60(75.3)	51.72(52.8)	67.55(194.0)
V	8.21(63.3)	5.61(77.2)	36.33(38.7)	50.15(179.3)
Average	9.82(78.6)	6.24(89.95)	52.03(52.2)	68.08(215.8)

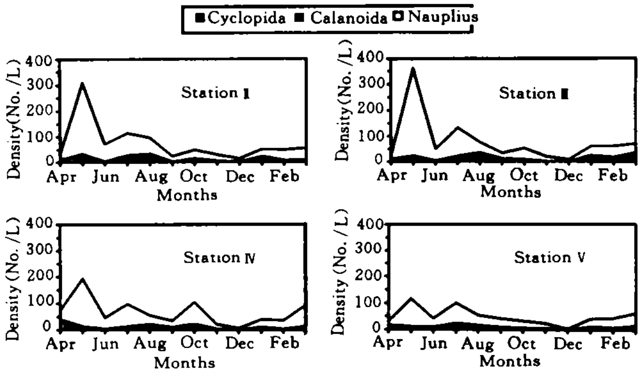

Fig. 2 Seasonal changes in density of Cyclopoida (copepodids + adults), Calanoida (copepodids + adults) and nauplius at four stations in Lake Biandantang.

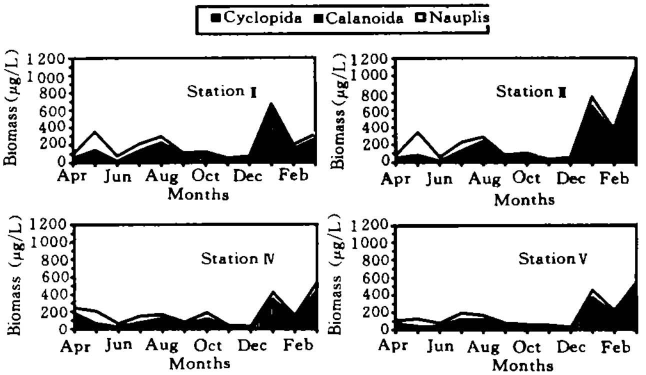

Fig. 3 Seasonal changes in biomass of Cyclopoida (copepodids + adults), Calanoida (copepodids + adults) and nauplius at four stations in Lake Biandantang.

Figs. 2— 3 show the seasonal changes in density and biomass of Cyclopoida (copepodids + adults), Calanoida (copepodids + adults) and nauplius at four stations in Lake Biandantang. Generally, the population density of Copepoda was higher in the spring and the early summer, which was mainly composed of nauplius; while a relatively higher Copepoda biomass occurred in the winter season, which was mainly composed of *C. vincinus vincinus* a widespread species in Europe and Asia.

On annual average density, the ratio of nauplius to total Copepoda ranged from 0.72(St. V) to 0.78 (St. I) with a mean of 0.76 for the four sampling stations. It reflected a density pyramid from nauplius to adults. However, in terms of biomass, this ratio was as low as 0.20(St. III) – 0.27(St. IV)(the mean 0.24) (Tab. 2). Although the annual average densities of Cyclpoida were obviously higher than those of Cyclopoida, the biomass of the latter was higher than that of the former in most cases.

3 Discussion

Tab. 3 shows a comparison of the species composition of planktonic copepods in

Tab. 3 Comparison of the species composition of copepods in several macrophyic shallow lakes along the middle and lower basins of the Changjian River

Lake Name	L. Honghu	L. Biandantang	L. Donghu	L. Hongze	L. Wulihu[1]
Period of study	1992.7—1993.4 1981.6—1982.5	1996.4—1997.3	1962.4—1963.5 1995.1—1995.12	1987.12—1989.11	1950.11—1951.11
Cyclopoid					
Limnoithona sinensis (Burckhardt, 1913)				*	
Macrocyclops albidus (Jurine, 1820)	+	+	+		+
Eucyclops macruroides denticulatus (Graeter, 1903)	+	+			
E. macruroides (Lilljeborg, 1901)					+
E. serrulatus (Fisher, 1851)	+		+	+	+
E. speratus (Lilljeborg, 1901)			+		
E. euacanthus (Sars, 1909)	+				
Ectocyclops phaleratus (Koch, 1838)	+	+			
Paracyclops fimbriatus (Fischer, 1853)			+		
Cyclops vincinus vincinus Uljanin, 1875	*	*	*	+	+
C. strenuus Fischer, 1851					+
Acanthocyclops viridis (Jurine, 1820)	+		+	+	+
Microcyclops varicans (Sars, 1963)	+	*	+		
M. rubellus (Lilljeborg, 1901)	+				
M. javanus (Kiefer, 1929)	+				
Mesocyclops notius, Kiefer, 1981		*	*		
M. leucharti (?)	*			*	+
Thermocyclops taihokuensis Harada, 1931	+	*	*	*	+
T. brevifurcatus Harada, 1931	+	*			
T. hyalinus (Rehberg, 1880)	+		+	+	+
T. dybowskii (Lande 1890)	+				
T. mongolicus Kiefer, 1937	+				
Neoergasilus sp.		+			
Sinergasilus sp.			+		
Calanoida					
Sinocalanus dorrii (Brehm, 1909)	*	*	*	*	+
Schmackeria forbesi Poppe et Richard	*	*	*	*	+
S. inopinus (Burckhardt, 1913)				*	+
Neodiaptomus schmackeria (Poppe et Richard,1892)	+	+	+	+	+
N. yantsekiangensis Mashiko, 1951	*	*	*	+	+
Neutrodiaptomus incongruens (Poppe, 1888)			+	*	+
Phyllodiaptomus tunguidus Shen et Tai, 1964	+	+			
Eudiaptomus sinensis (Burckhardt, 1913)	+		+		+
Tropodiaptomus oryzanus Kiefer, 1937	+				+
Mongolodiaptomus birulai (Rylov, 1923)	+			+	+
Sinodiaptomus sarsi (Rylov, 1923)					+
Total cyclopida	16	9	11	7	9
Total calanoida	8	5	6	7	11
Cyclpoida+calanoida	24	14	17	14	20

[1] No available data about dominant species; + *Present*; * *Dominant species*

Data Sources: Lake Honghu: He & Fan (1986), Zheng (1995); Lake Biandantang: Present study; Lake Donghu: Chen (1965), Xie et al. (1996); Lake Hongze: Chen (1993); Lake Wulihu: Pai, (1962) five macrophytic lakes in the middle and lower basins of the Changjiang River. Tab. 4 gives a comparision of the physical dimensions and macrophyte biomass in these lakes. Obviously, the species number of planktonic copepoda in Lake Hongze (a very large lake) and Lake Biandantang (a small lake) is relatively lower than in the three other lakes, possibly due to the short study period or some unknown reasons. It seems that the species number of Copepoda is not proportional to the surface area of the lake in this region, which is not coincident with Dodson's conclusion on the positive relationship of lake surface area vis-à-vis cladocera species number in European and North American lakes (Dodson, 1991, 1992). This is probably because that the middle and lower basins of the Changjiang River are a kind of flood plain whose lakes are not only interconnected with the river, but also directly mixed during the flooding season, i.e., there occurs a relatively sufficient exchange of organisms among lakes.

In China, there are as many as 63 endemic planktonic copepod species (25 cyclopoida and 38 Calanoida) (Shen, 1979). However, in the middle and lower basins of the Changjiang River, although their lake area constitutes ca. 1/4 of the total lake area in China, there are only four endemic species, i.e., *Neutrodiaptomus alatus* Hu, 1943, *Neutrodiaptomus lianshanensis* Shen et Sung, 1975, *Eodiaptomus sinensis* (Burckhardt, 1932), and *Tropocyclops brevispinus* Shen et Tai, 1962, among which *E. sinensis* distributes relatively widely in this region while the others are only reported

Tab.4 Comparison of the physical dimensions and macrophyte biomass of five shallow lakes along the middle and lower basins of the Changjian River

Lake Name	Lake Honghu	Lake Biandantang	Lake Donghu	Lake Hongze	Lake Wulihu
Latitude & Longitude	29° 49'N, 113° 17'E	30° 15'N, 114° 23'E	33° 33'N, 114° 23'E	(33° 06'—33° 40')N (118° 10'—118° 52')E	31° 30'N, 120° 36'E
Mean Depth (m)	1.35	1.3—1.9	2.2	0.77—2.40	2
Maximum Depth (m)	2.32	——	4.75	3.0—5.0	4
Surface area (km^2)	344	3.3	27.9	1120—1613	7.8
Biomass of Macrophytes (g w. w./m^2)	5569(S)	2520(S)	1068(T)	2999(T)	abundant
Data sources of macrophytes	Li(1995)	Su et al.(1995)	Chen(1973)	Zheng(1993)	

S: submerged macrophytes; T: total macrophytes

from one lake or very limited places.

The dominant Cyclopoida in these lakes are usually *C. vincinus vincinus*, *Mesocyclops notius* (in two lakes, recorded as *M. leucharti*, but we consider it to be *M. notius*), *Theremocyclops taihokuensis* occasionally associated with *T. brevifucatus* and *T. hyalinus*, except for Lake Hongze (close to the Yellow Sea) where *C. vincinus vincinus* is replaced by *Limnoithona sinensis* which widely distributes in brackish waters or freshwaters along the coasts of sea (Shen, 1979). The dominant Calanoida in the five lakes are *Sinocalanus dorrii, schmackreia forbesi* and *N. yantsekiangensis*, except for Lake Hongze where *N. yantsekiangensis* is replaced by *schmackeria inopinus*, a species more commonly found in brackish water than in freshwaters (Shen, 1979). Occasionally, *Neutrodiaptomus incongruens* also dominates. It appears that although there are as many as 35 species of planktonic Copepoda in these lakes, the dominants are quite similarly limited to a few genus or a few species, while the most other species only appear incidentally.

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浅水草型湖泊
——扁担塘中桡足类的群落结构

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摘要 本文研究了一浅水草型湖泊——扁担塘中桡足类的群落结构,包括种类组成、种群动态及现存量。在一周年的研究中,共发现 14 种浮游桡足类(9 种剑水蚤和 5 种哲水蚤)。根据年平均密度,剑水蚤的优势种为: *Mesocyclops notius*, *Cyclops vincinuis vincinus* 和 *Thermocyclops brevifurcatus*, 而哲水蚤的优势种为 *Neodiaptomus yantsekiangensis* 和 *Sinocalanus dorrii*。通过比较长江沿岸的 5 个湖泊的桡足类的种类组成发现,桡足类的种类数并不与湖泊面积大小成正比,这与 Dodson 通过研究欧洲及北美湖泊中的枝角类得出的结论并不一致。此外,虽然这 5 个湖泊中的桡足类的种类数多达 35 种,但每个湖泊中的优势种都非常相似地集中到少数几个属或种,而其它均为偶尔性种类。

关键词: 桡足类, 亚热带湖泊, 物种丰度, 沉水植物, 生态学研究