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PRELIMINARY STUDIES OF MACROINVERTEBRATES OF THE MAINSTREAM OF THE CHANGJIANG (YANGTZE) RIVER

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Abstract Surveys of macro-invertebrates in mainstream of the Changjiang River were carried out for four times in 1989—1997. Altogether 2 polychaetes, 35 oligochaetes, 50 insects, 26 molluscans and 10 miscellaneous animals were recorded. The distribution of many taxa are not obviously regional except that of the polychaetes which are limited in lower river. On the basis of species, functional feeding groups were determined, showing that 8 species (6.5% of the total) are shredders, 58 (47.1%) are collectors, 38 (30.9%) are grazers and 19 (15.5%) are predators. The mean densities of macroinvertebrates in upper, middle and lower reaches were 6487.5, 2737.5 and 1181.3 ind·m^{-2}, respectively. The oligochaetes were the dominant group in entire river. Regarding the biomass (wet weight), the greatest amount was found in middle reaches, up to 29.986 g·m^{-2}. Biomass in other reaches were lower, being 2.868 g·m^{-2} in upper reaches and 11.643 g·m^{-2} in lower reaches. The relationships between macroinvertebrates and main environmental factors were analyzed, showing that the species richness of macroinvertebrates were significantly correlated with certain factors such as current velocity, water temperature and transparency. Especially, a very significant correlation was found between macroinvertebrates and water depth during higher water period of the river.

Key words Macroinvertebrates, Changjiang River, Functional feeding groups, Density, Biomass

1 Introduction

Being the largest river in China and the third in the world, the Changjiang River originates in the middle part of the Tanggula Shan and flows through eight provinces, two municipality and one autonomous region. It has a total length of more than 6300 km, and a catchment area of 1808500 km^2. Geographically, the river can be divided into three reaches: Chongqing down to Yichang of Hubei Province is the upper reaches; from Yichang down to Hukou of Jiangxi Province is the middle reaches and from Hukou to the mouth of the river is the lower reaches.

Macroinvertebrates, the invertebrates that do not pass through a net with mesh size of 500 μm (Higgins, 1988), form an important part of detritus decomposers of the river ecosystem (McQueen *et al.*, 1986) and contribute to food resources for fish (Keast, 1985). They have also been used for biomonitoring (e.g. Chessman, 1995; Parsons & Norris, 1996) and assessing ecological conditions of rivers (e.g. Smith *et al.*, 1999; Richard *et al.*, 1999). However, owing to the difficulties of taking benthic samples from a large river, the macroinvertebrates in the Changjing River were paid less attention than those in lakes and other lentic waters. As a result, The macroinvertebrates in the mainstream of the river were still poorly known (Liang, 1987; Liang *et al.*, 1985; Wu & Chen, 1986; Chen & Wu, 1983).

Aiming at an evaluation of the potential effect of the Three Gorges Hydro-electric Project on the river system, four surveys of macroinvertebrates in mainstream of the Changjiang River were carried out in 1989—1997. The results hitherto obtained are given in this present report.

2 Study area

Three major geographical reaches with a total length of 1960 km (Fig. 1, 2) of the mainstream of the river were studied. From Chongqing to Yichang (900 km in distance) represents the upper reaches with a narrow valley and a rocky channel of high gradient ratio; the current is torrential, and erosion prevails in this section. From Yichang to Hukou, ca. 660 km away, is the middle reaches. Here the river broadens out and takes a meandering course, accompanied by the development of sandbars. Here also, as a result of deposition in geological ages, the vast alluvial plain of the Changjiang River was formed. On the plain, many shallow lakes interlace with the network of the water system and present the characteristic landscope of a "water country". Dongting Lake, Poyang Lake and Chao Lake are among the largest lakes of this area. From Hukou down to Nanjing belongs to lower reaches, with a length of about 400 km and an elevation of not more than 10 m above sea level (Liu, 1984).

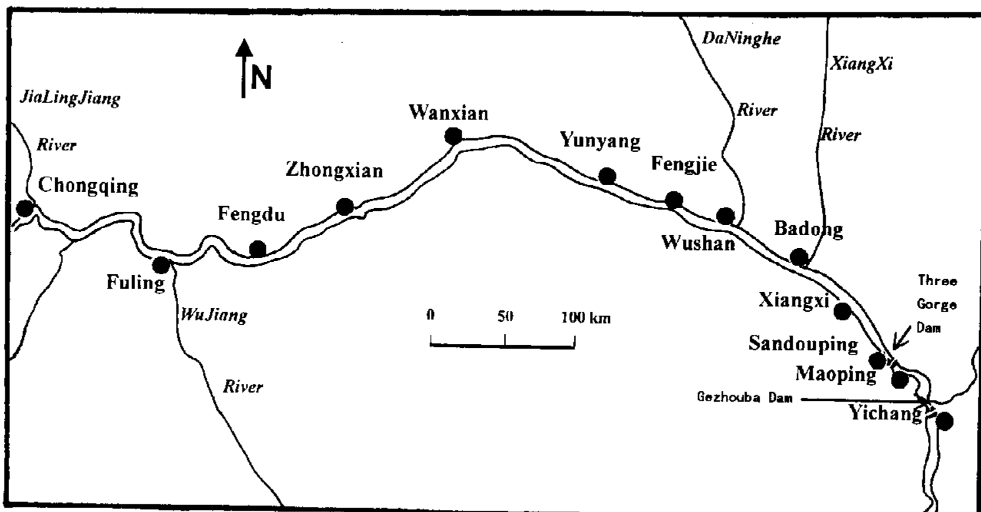

Fig. 1 Sampling sites of macroinvertebrates in upper reaches of the Changjiang River

3 Materials and methods

Samplings of macroinvertebrates in mainstream of the Changjiang River were made for four times in March-April, 1989, October, 1996, June and October, 1997. Altogether 30 sampling sites were set up along the river (Fig. 1, 2). Qualitative and quantitative samples were taken with a weighed, modified Petersen grab (1/16 m^2 in area), and sieved with a copper sieve (mesh size 162 μm). Benthic specimens were picked up through naked eyes and preserved in 10% formalin. The standing crops and relevant data of experiment were calculated by means of routine way. All statistical analyses were performed on a personal computer with the Statistica program by Statsoft Inc (1995).

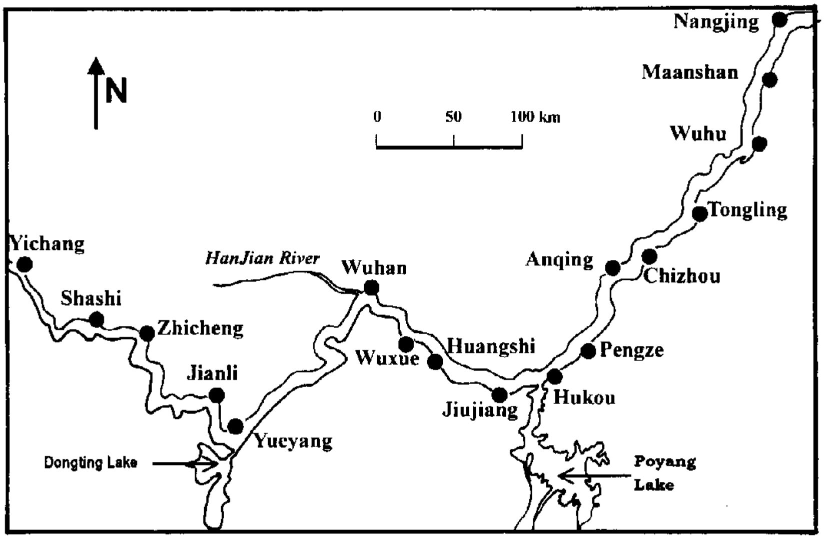

Fig.2 Sampling sites of macroinvertebrates in mid-lower reaches of the Changjiang River

4 Results and discussions

4.1 Physico-chemical conditions

Tab.1 shows the major physico-chemical parameters measured in October, 1997. It reveals that water

Tab.1 Physico-chemical properties in mainstream of the Changjiang River

Sites	Vel (m/sec)	WT (℃)	SD (cm)	pH	COND (μs/cm)	COD (mg/L)	PO_4^{2-} (mg/L)	TP (mg/L)	TN (mg/L)	NO_2^- (mg/L)	NO_3^{2-} (mg/L)
Chongqing	0.5	18.8	8.0	8.82	282	2.034	0.032	0.053	0.451	0.036	0.575
Fulin	>1.0	18.8	7.0-8.0	8.56	300	2.577	0.039	0.023	0.287	0.021	0.623
Fengdu	2.0	18.5	7.0-8.0	8.55	370	2.306	0.006	0.053	0.385	0.015	0.561
Wanxian	>2.0	18.5	9.0	8.46	321	2.848	0.022	0.031	0.519	0.017	0.420
Yunyang	>2.0	19.0	9.0	8.79	318	1.854	0.026	0.058	0.837	0.014	0.842
Fengjie	>2.0	19.0	9.0	8.78	320	1.854	0.030	0.114	0.530	0.021	0.780
Wushan	>2.0	18.8	10.0	8.82	359	1.854	0.041	0.056	0.876	0.017	0.856
Maoping	1.5	18.5	9.0	8.71	310	1.854	0.033	0.046	0.826	0.012	0.753
Yichang	2.0	19.0	12.0	8.71	305	1.763	0.051	0.062	0.678	0.020	0.660
Shashi	>1.5	18.5	10.0	8.78	350	1.944	0.036	0.055	0.725	0.019	0.712
Yueyang	0.3	22.0	35.0	8.54	221	2.215	0.030	0.073	0.807	0.044	0.684
Wuhan		18.5		8.57	270	3.165	0.030	0.123	0.761	0.016	0.724
Hukou	0.2	21.0	8.0	6.55	200		0.020	0.095	1.040	0.012	0.561

current velocity (Vel), conductivity (COND) in upper reaches were higher than mid-lower reaches, but the water temperature (WT), transparency (SD), chemical oxygen demand (COD), total phosphorus contents (TP) and total nitrogen contents (TN) increased along the river downwards. The lowest pH value occurred in Hukou may have been related to the acid soil. The highest TN in Hukou and TP in both Hukou and Wuhan seemed to be affected by organic pollution.

4.2 Species composition

Altogether 56 families, 112 genera and 123 species (Tab. 2), *viz*. 2 polychaetes, 35 oligochaetes, 50 insects, 26 molluscans and 10 miscellaneous animals were identified. The dominant forms throughout the river were oligochaetes and insects that comprised 71.7% of taxa collected. Molluscans were also frequent, especially in lower reaches, up to 20% of total taxa.

Tab.2 Species of macroinvertebrates occurring in the mainstream of the Changjiang River

	Upper reaches	Middle reaches	Lower reaches
Polychaeta			
Nephthys sinensis			+
N. polybranchia			+
Oligochaeta			
Chatogaster diastrophus	+		
Paranais frici	+	+	+
Nais variabilis	+		
N. sp.			+
N. inflata	+	+	+
N. pardalis	+		+
N. bretscheri			
Arcteonais lomondi			+
Allonais sp.	+		
Slavina appendiculata		+	
Dero digitata		+	+
D. dorsalis			+
Aulophorus furcatus	+	+	+
Stephensoniana trivandrana	+		
Pristinella osborni	+		
Tubifex tubifex	+	+	
T. sp.	+	+	+
Spirosperma nikolskyi			+
Bothrioneurum vejdovskyanum			
Limnodrilus hoffmeisteri	+	+	+
L. claparedeianus	+		
L. grandisetosus		+	+
L. udekemianus		+	
L. sp.	+	+	
L. silvani		+	
Teneridrilus mastrix		+	+
Isochaeta sp.	+		
Aulodrilus pigueti		+	+
A. pluriseta	+	+	
Rhaycodrilus sinicus			+
R. riabuschinskii	+		
R. sp.		+	
Monopylephorus limosus	+	+	
Telmatodrilus sp.		+	
Branchiura sowerbyi	+	+	+
Marionina sp.	+		
Insecta			

(Cotinued)

	Upper reaches	Middle reaches	Lower reaches
Clinotonypus sp.	+	+	+
Procladius choreus		+	+
P. sp.	+		+
Pelopia sp.	+		
P. *punctipennis*			+
Cricotopus exilis			+
Eukiefferiella sp.			+
E. *sylvestris*			+
Tanytarsus sp.			+
Pentaneura monilis			+
P. sp.			+
P. *flavifron*			+
Rheotanytarsus sp.	+		
Micropsectra sp.	+		
Endochironomus nifricans			+
E. sp.	+	+	
Polypedilum scalaenum			+
P. *leucopus*			+
P. *breviantennatum*			+
P. sp.	+	+	
Glyptotendipes sp.	+		
C. *digitatus*			+
C. *fuscimanus*			+
C. *anomalus*			
C. *conjugens*			+
Gryptochironomus sp.	+	+	+
Microchironomus sp.		+	
Stictotendipes lavingula			+
Harnischia anomalus			+
Chironomus sp.	+		
Orthocladius sp.	+		
Pupae	+		
Ecdyuridae	+		+
Caenidae	+		
Ephemerillidae	+		+
Gomphidae	+		+
Pytiscidae	+		
Gomphus sp.		+	
Ephemera vulgata		+	+
Caenis macrura			+
Cetatopogonidae	+	+	+
Psychodidae	+		
Caloprer yx atrata			+
Osmylus sp.			+
Orthotrichia tetensii			+
Polycentropus sp.			+
Hydropsyche sp.		+	+
Ecnomus tenellus		+	+
Leptocerus sp.			+
Phryganea sp.			
Limnophilus sp.			
Nerreclipsis sp.			
Coleoptera		+	
Helodes sp.		+	+
Setodes sp.			+
Mollusca			

(Cotinued)

	Upper reaches	Middle reaches	Lower reaches
Cipangopaludina sp.			+
Bellamya angularis			+
B. aeruginosa			+
B. sp.	+		
Alocinma longicornis			+
Parafossarulus striatulus			+
Melanoides tuberculata		+	
Semisulcospira cancellata		+	+
S. mandarina		+	+
S. pleuroceroides	+		
S. libertina			+
S. sp.		+	+
Taretia gianitera		+	
Melania sp.			+
Radix perger			
Radix lagotis	+		
Galba truncatuta	+		
Gyranlus compressus	+		
G. albus	+	+	
Stenothyra glabra	+		+
anodonta woodiana		+	
Lanceolaria grayana			
limnoperna lacustris	+	+	+
Novaculina chinensis			+
Corbicula fluminea		+	+
C. leana		+	+
Corbicula largillierti	+		
Miscellaneous animals			
Nematoda	+		+
Amphipoda	+	+	+
Isopoda		+	
Ostracoda			+
Glossiphonia sp.			+
Hirudinea	+	+	
Hydrocarina			+
Palaemonates sp.		+	
Grapsoid crab		+	
Aquatic spiders		+	

Although many taxa are rather common in Chinese freshwaters and distributed without significant demarcation in the river, there are some aspects worthy of being mentioned. First, the occurrence of some oligochaetes is remarkable. In addition to the rheophilous naidid, *Nais inflata* Liang, which is endemic and commonly distributed throughout the river, *Nais* sp., closely related to *Nais inflata* and perhaps new to science, only occurs in lower reaches but less abundant. An enchytraeid *Marionina* sp. occurring in soil habitats along upper reaches, and in a shallow lake (Ban'an Lake) in middle reaches (Xie, personal observing) has also been described to be new to science (Xie & Rota, In prep.). Secondly, previous records (Liang *et al.*, 1985) indicated that Anqing is the upper distributional limit of polychaetes in the Changjiang River. In our investigation, however, two species of polychaetes, *Nephthys sinensis* and *Nephthys polybranchia*, may also be distributed up to Hukou. Since the polychaetes are generally regarded as marine invertebrates, it implies that macroinvertebrates in lower reaches should have historically been affected by marine fauna. It also implies that Hukou is the reasonable demarcation between middle and lower reaches.

Tab. 3 gives the species richness of three reaches. The highest richness (74 taxa) was found in lower reaches, especially, the insects and molluscans are more frequent groups, being 36 and 14 respectively. For molluscans, it seems that some physico-chemical conditions in lower river such as slower current velocity and conductivity, as well as higher water temperature and transparency, are more favourable to that phylum (see discussion).

Tab.3 Number and percentage of taxa of different groups in the Changjiang River

	Upper reaches		Middle reaches		Lower reaches	
	number	%	number	%	number	%
Polychaeta					2	2.8
Oligochaeta						
Naididae	8	15.4	5	10.4	7	9.7
Tubificidae	11	21.2	14	29.2	8	11.1
Enchytraeidae	1	1.9				
Total	20	38.5	19	39.6	15	31.3
Insecta	19	36.5	13	27.1	36	50.0
Mollusca						
Gastropoda	7	13.5	6	12.5	10	20.8
Lamellibranchia	2	38.9	4	8.3	4	5.6
Total	9	17.3	10	20.8	14	19.4
Other animals	3	5.8	6	12.5	5	6.9
Total	52	100	49	100	74	100

4.3 Functional feeding groups

On the basis of species, the functional feeding groups in different reaches were determined by means of the authors' field observation and available literatures (e. g. Wetzel, 1983; Armitage *et al*., 1995) in combination (Tab. 4). It reveals that there are no significant difference among three reaches except for the predators that are more abundant in lower reaches. In entire river, results showed shredders and predators are few, only 8 (6.5% of the total) and 19 (15.5%) species respectively, while collectors and grazers are more frequent groups, being 58 (47.1%) and 38 (30.9%).

Tab.4 Functional feeding groups of macroinvertebrates in different reaches of the Changjiang River

	Upper reaches	Middle reaches	Lower reaches	Entire river
Shredder	1	3	7	8
Collector Filterer	7	6	11	18
Collector Gatherer	18	18	19	35
Totals of Collector	25	24	30	58
Grazer	16	12	17	38
Predator	6	7	13	19
Totals	48	46	67	123

4.4 Density and biomass

The mean densities and biomass in three reaches during 1989 to 1997 are given in Tab. 5. It indicates that, although their biomass were lower, oligochaetes constitute the majority of the density throughout the river, being 52.8—97.3% of the total. However, the abundance of oligochaetes was somewhat different in different reaches. Tubificids were more abundant in mid-lower reaches (48% and 90% respectively), while naidids were more frequent in upper reaches (83.3%). Taking density and biomass into consideration, Molluscan, mainly occur in mid-lower reaches, was the dominant group in middle reaches, being 41.9% and 93.0% of the total, respectively.

Tab.5 Mean densities and biomass of macroinvertebrates in the Changjiang River

	upper reaches		middle reaches		lower reaches	
	Density ($ind \cdot m^{-2}$)	Biomass ($g \cdot m^{-2}$)	Density ($ind \cdot m^{-2}$)	Biomass ($g \cdot m^{-2}$)	Density ($ind \cdot m^{-2}$)	Biomass ($g \cdot m^{-2}$)
Oligochaeta						
Naididae	2280	0.825	56.5		474.7	0.053
Tubificidae	257.5	1.28	566.6	1.634	5839.5	6.647
Total	2537.5	2.105	623.1	1.634	6314.2	6.700
Insecta	200	0.763	63.3	0.474	67.3	0.082
Mollusca			494.9	27.878	106.0	4.861
Total	2737.5	2.868	1181.3	29.986	6487.5	11.643

4.5 Discussion

The majority of macroinvertebrates in the Changjiang River appears to be more or less composed of rheophilic taxa. Compared to the fauna in shallow lakes or other lentic waters along the Changjiang Basin (Liang *et al.*, 1995a, b; Xie *et al.*, 1996; Wang *et al.*, 1996), 46 taxa found in the Changjiang River have not been recorded in lakes. Among them are some naidids and tubificids (e.g. *Rhyacodrilus riabuschinskii*, *Telmatodrilus* sp.), Caenidae, Ephemerillidae, Psychodidae, *Osylus* and *Setodes* (insects), and *Melanoides* and *taretia* (molluscans). Probably part of the difference are due to the different temperature range (Liang, 1987), lower transparency and higher current velocity (Wu & Chen, 1986; Chen & Wu, 1983).

Tab.6 Correlations between species richness of macroinvertebrates and physico-chemical parameters (df = 11, * $p < 0.05$)

	Naididae	Tubificidae	Oligochaeta	Insecta	Mollusca	Totals
Vel	-0.52	-0.23	-0.42	-0.48	-0.63*	-0.69*
Wt	0.18	0.03	0.12	0.00	0.88*	0.45
SD	-0.34	-0.12	-0.28	-0.22	0.86*	0.20
pH	-0.66*	-0.24	-0.52	-0.24	-0.33	-0.46
COND	-0.48	-0.38	-0.47	-0.46	-0.74*	-0.74*
COD	0.49	0.28	0.43	0.41	0.33	0.52
Hardness	0.24	0.11	0.22	0.33	-0.32	0.02
PO_4^{2-}	-0.29	0.29	0.02	0.08	-0.06	0.01
TP	0.27	-0.09	0.11	-0.01	0.23	0.14
NO_2^-	0.03	0.21	0.13	0.24	0.61*	0.50
NO_3^{2-}	-0.46	-0.69*	-0.63*	-0.41	-0.04	-0.51
NH_4^+	0.65*	0.46	0.63*	0.64*	0.01	0.60*
TN	-0.08	-0.38	-0.25	-0.37	0.26	-0.20

The relationships between species richness of macroinvertebrates and physico – chemical factors were analyzed (Tab. 6). It showed that oligochaetes are negatively correlated with NO_3^{2-} and positively with NH_4^+, while molluscans are significantly correlated with many factors such as current velocity, water temperature, transparency, conductivity and NO_2^-.

The relationships between standing crops of macroinvertebrates and physico – chemical factors in lower and higher water periods were analyzed (Tab. 7, 8). In higher water, depth was the main limit factor impacting the distribution of the macroinvertebrates. In lower water level, however, many factors such as water temperature, transparency and pH were more important.

Tab.7 The correlation between standing crops and physico – chemical parameters in lower water level period ($df = 16$, * $p < 0.05$) (D, density; B, biomass)

		Wt	SOD	Depth	Bt$^{\Psi}$	pH	TP	NO_3^{2-}	TN
Naididae	D	0.13	-0.32	-0.11	0.15	0.13	0.15	-0.07	-0.08
	B	0.13	-0.32	-0.11	0.16	0.13	0.15	-0.06	-0.07
Tubificidae	D	0.28	-0.28	-0.23	0.23	0.05	-0.10	-0.04	0.01
	B	0.33	-0.47	-0.13	-0.30	0.17	-0.11	-0.14	-0.05
Oligochaeta	D	0.26	-0.30	-0.22	0.23	0.07	-0.06	-0.05	0.00
	B	0.33	-0.47	-0.13	0.30	0.17	-0.11	-0.14	-0.06
Insecta	D	0.14	-0.09	0.24	-0.04	-0.11	-0.57*	0.51*	-0.12
	B	-0.12	0.04	-0.26	-0.12	-0.18	-0.40	0.92*	-0.17
Mollusca	D	-0.61*	0.87*	-0.22	-0.34	0.59*	0.11	-0.07	0.32
	B	-0.61*	0.86*	-0.23	-0.33	0.60*	0.10	-0.07	0.32
Totals	D	-0.36	0.60*	-0.34	0.14	0.56*	0.04	-0.07	0.26
	B	-0.60*	0.86*	-0.24	-0.32	0.60*	0.10	-0.07	0.31

$^{\Psi}$ bottom temperature

Tab.8 The correlation between standing crops and physico-chemical parameters in higher water level period ($df = 16$, * $p < 0.05$) (D, density; B, biomass)

		Wt	SOD	Depth	Bt$^{\Psi}$	pH	TP	NO_3^{2-}	TN
Naididae	D	0.17	0.14	0.56*	-0.09	-0.07	-0.13	-0.27	-0.28
	B	0.17	0.14	0.56*	-0.09	-0.07	-0.13	-0.27	-0.28
Tubificidae	D	0.21	0.14	0.61*	-0.10	-0.07	-0.17	-0.28	-0.30
	B	0.22	0.12	0.61*	-0.11	-0.02	-0.01	-0.21	-0.21
Oligochaeta	D	0.21	0.14	0.61*	-0.10	-0.07	-0.12	-0.28	-0.30
	B	0.22	0.12	0.61*	-0.11	-0.02	0.01	-0.21	-0.21
Insectea	D	0.15	0.21	-0.12	-0.07	0.14	0.03	0.09	0.05
	B	-0.02	0.33	-0.11	-0.40	-0.25	-0.05	-0.38	-0.20
Mollusca	D	0.05	-0.13	0.19	-0.05	0.53*	-0.24	0.33	0.24
	B	0.21	0.11	0.33	-0.03	0.43	-0.25	0.17	0.14
Totals	D	0.21	0.14	0.61*	-0.10	-0.06	-0.13	-0.27	-0.30
	B	0.26	0.16	0.59*	-0.10	0.16	-0.11	-0.09	-0.10

$^{\Psi}$ bottom temperature

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References

Armitage, P., P. S. Cranston, C. V. Pinder, 1995. The Chironomidae, the biology and ecology of non-biting midges. London: Chapman & Hall, 1—572.

Chen, Q. Y., T. H. Wu, 1983. Ecological aspects of Mollusca in the lower reaches (Nanjing to Jiangyin) of Changjiang River (the Yangtze River). *Transactions of the Chinese Society of Malacology* (*No*. 1). Beijing: Science Press, 103—114. (In Chinese with English abstract)

Chen, Q. Y., T. H. Wu, 1990. Main biotic communities and successions-zoobenthos. In: J. K. Liu (ed.), Ecological study on Donghu Lake (No. 1). Beijing: Science Press, 129—152. (In Chinese)

Chessman, B. C., 1995. Rapid assessment of rivers using macroinvertebrates: a procedure based on habitat-specific sampling, family level identification and a biotic index. *Aust*. *J*. *Ecol*. **20**: 122—129.

Higgins, P. R., H. Thiel, 1988. Introduction to the study of merofauna. Washington: Smithsonian Institution Press, 1—20.

Keast, A., 1985. Planktivory in a littoral-dwelling lake fish association: prey selection and seasonality. *Can*. *J*. *Zool*. **62**: 1289—1303.

Liang, Y. L., J. Wang, X. J. Liu, L. J. Lin, 1985. Hydrobiological studies on the region of the projected Sanxia Reservoir of the Changjiang (Yangtze) River-1985 Research report. (Unpublished).

Liang, Y. L., T. H. Wu, Z. C. Xie, 1995. A preliminary investigation of zoobenthos and its potential fishery production capacity in Xiliang Lake. In: Y. L. Liang, H. Q. Liu (eds), Resource, environment and fishery ecological management of macrophytic lakes (No. 1). Beijing: Science Press, 194 - 204. (In Chinese with English abstract)

Liang, Y. L., T. H. Wu, Z. C. Xie, 1995. On the current conditions of zoobenthos in Baoan Lake with an assessment of its potential fishery production capacity. In: Y. L. Liang, H. Q. Liu (eds), Resource, environment and fishery ecological management of macrophytic lakes (No. 1). Beijing: Science Press, 178 - 192. (In Chinese with English abstract)

Liang, Y. L., 1987. Preliminary study of the aquatic Oligochaeta of the Changjiang (Yangtze) River. *Hydrobiologia*, **155**: 195—198.

Liu, J. K., 1984. Lakes of the middle and lower basin of the Changjiang (China). In : F. B. Taub (ed.), Lakes and Reservoirs. Elsevier: Sci. Publ. Co., 331—355.

McQueen, D. J., J. R. Post, E. L. Mills, 1986. Trophic relations in freshwater pelagic ecosystem. *Can*. *J*. *Fish*. *Aquat*. *Sci*., **43**: 1571—1581.

Parsons, M., R. H. Norris, 1996. The effect of habitat-specific sampling on biological assessment of water quality using a predictive model. *Freshw*. *Biol*. **36**: 419—434.

Richard H., M. C. Thoms, 1999. What is river health? *Freshw*. *Biol*. **41**: 197—207.

Smith, M. J., 1999. AusRivAs: using macroinvertebrates to assess ecological condition of rivers in Western Australia. *Freshw*. *Biol*. **41**: 269—282.

Wang, X. D., 1996. The effects of eutrophication on the diversity of zoobenthos in Donghu Lake. *Acta Hydrobiol*. *Sinica* **20** (suppl.): 75—89. (In Chinese with English abstract)

Wetzel, R. G. (ed.), 1983. Limnology (second edition). Philadelphia: Saunders College Publishing, 1—462.

Wu, T. H., Q. Y. Chen, 1986. Densities and distribution of zoobehthos in the lower reaches (Nanjing-Jiangyin section) of Changjiang (the Yangtze) River. *Acta Hydrobiol*. *Sinica* **10**: 74—85. (In Chinese with English abstract)

Xie, Z. C., Y. L. Liang, T. H. Wu, 1996. Diversity of zoobenthos in lakes in the medium reaches of Changjiang River. *Acta Hydrobiol*. *Sinica* **20** (suppl.): 103—113. (In Chinese with English abstract)