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NOTE

Brackish Lakes in Shinpo District, North Korea. I. Zooplankton

Kim, Saywa* and Yeon-Shik Kang[1]

(*Division of Environmental Biology, Yong-In University, Yongin 449-714, Korea*
[1]*Environmental Research Group, Korea Electric Power Research Institute, Taejon, 305-380, Korea*)

북한 신포지구의 기수호 I. 동물플랑크톤. 김세화* · 강연식[1] (용인대학교 환경생명학부, [1]한수원 전력연구원)

북한 신포지구에 위치하는 3개 호수는(호만포호, 현금호, 대인호) 동물플랑크톤 출현 결과와 염분도로(현금호는 2002년 5월과 10월에 2.8ppt와 0.8ppt, 대인호는 1.5 ppt와 0.5 ppt) 보아 기수호임이 밝혀졌다. 3개 호수에서 출현한 34종류의 동물플랑크톤 중 요각류와 윤충류가 각각 15종과 7종 동정되었으며 34종류 중 담수종은 24종, 기수종과 해산종은 각각 6종과 4종이었다. 기수성 요각류인 *Pseudodiaptomus inopinus*와 *Sinocalanus tenellus*는 3개 호수에 모두 분포하고 있었으며 3개 호수 모두에서 기수종과 해산종의 출현양이 동물플랑크톤 출현양의 90% 이상을 차지하고 있었다. 5월에 현금호에서 *S. tenellus*가 입방미터당 59,000개체로 대량 출현하여 이때 기수종과 해산종의 출현양은 전체 동물플랑크톤 출현양의 99%를 넘었다. 연구 지역의 기수호를 보호하기 위한 기초자료를 제공하기 위해서는 장기 조사가 필요한 것으로 나타났다.

Key words : brackish lake, zooplankton, Shinpo, North Korea

Water chemistry, primary productivity and fish yield data are comparatively more available than biological and water quality information in lakes (Herdendorf, 1990). Brackish lakes provide with a unique environment to biota and shows different ecology compared with freshwater lakes (Nixon, 1988). Although its number is much fewer than that of freshwater lakes, however, information of brackish fauna and flora are not well explored; only 15 brackish lakes were reported among 253 large lakes in the world by Herdendorf (1990).

Despite poor studies on brackish organisms, biomonitoring of estuarine animals has been carried out to know the harmful effect of bioaccumulation of toxic materials such as DDT and PCB (Wilber, 1969). Moreover brackish waters play an important role to connect the freshwater with marine ecosystem.

Ecology of brackish area was documented by Kurihara (1988). He pointed out the importance of brackish area for human activity, such as maritime industrialization, aquaculture and resort. Then, the ecotechnology was explained to develop maritime zone without destructing brackish ecosystem. Brackish lakes are well developed in coastal areas faceed with the East Sea (the Sea of Japan) in the Korean peninsula (Mizuno and Cho, 1980; Nakai and Hong, 1982). Previous studies on brackish fauna have been carried out in many lakes and estuaries in the Korean peninsula (Cho *et al.*, 1975 for the lake which face the East Sea, Hong *et al.*, 1969; Cho *et al.*, 1971; Kim, 1972; Hong and Shin, 1978; Choi and Chung, 1985; Choi *et al.*, 1985; Kim *et al.*, 2002 for the Yellow Sea, and Jhoo and Sheo, 1975 for the South Sea). Little information is, however, available in brackish lakes in the north part of Korean peninsula.

The objectives of the study is to evaluate the faunal characteristics of zooplankton in three lakes faced with the East Sea in Shinpo district,

* Corresponding Author: Tel: 031) 330-2778, Fax: 031) 337-1530, E-mail: swkim@yongin.ac.kr

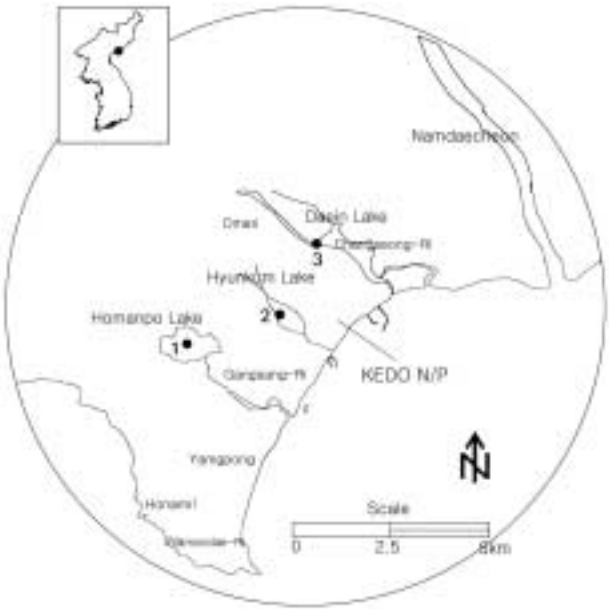

Fig. 1. Station map of three lakes in Shinpo district, North Korea.

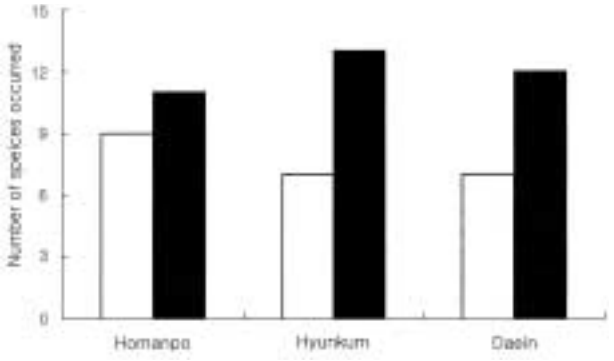

Fig. 2. Variation in the number of species occurred in three lakes of Shinpo district, North Korea. Open column: May 2002, solid: October, 2002.

North Korea.

Zooplankton samples were collected with a conical net (mouth diameter 30 cm, mesh aperture 0.1 mm) at three lakes in inland waters of Shinpo district, North Korea in May and October 2002. Names of three lakes are lake Homanpo (lake Yonghyun in DPRK name), lake Hyunkum and lake Daein, respectively (Fig. 1). A flowmeter (Hydrobios, Model 438 110) was equipped in front of the net mouth for the reading of filtered volume of waters through the net. Salinity was measured simultaneously at lake Hyunkum and Daein with a portable salinometer (YSI model 85). Sampling procedure differed with field situation due to the difference of the morphometry of three lakes. Pumping track for a rice paddy was used in May and oblique towing on board in October at lake Homanpo. At other lakes, a net was hauling with walking into the water due to the shallowness. Collected samples were placed in 300 ml volume bottle and preserved in 4% formaldehyde buffered with borax, then moved to the laboratory. More than 1/10 of zooplankters in each sample was examined and counted under a dissecting microscope (Zeiss SV11) (cf. Omori and Ikeda, 1984) with UNESCO counting chamber. Rotifers, copepods, cladocerans and mysids were identified to species under a compound microscope (Zeiss Auxiolab). Number of each taxa of zooplankton was converted to number per cubic meter of water by using of calculated volume of water through the net with flowmeter readings.

By definition, freshwater has a salinity of 0.5 ppt or less, and water that has salt between this value and about 17 ppt is said to be brackish (Milne, 1995). Salinities at lake Hyunkum were 2.8 ppt and 0.8 ppt, and 1.5ppt and 0.5ppt at lake Daein in May and October, respectively. In May 1998, salinities in two lakes (1.02 ppt and 1.49 ppt) had been measured to be more or less lower than results of the present survey. And the present survey in October showed the lower salinities than those in October 1998 (1.06 ppt and 1.13 ppt) in both lakes. With previous records and present measurements, two lakes are enough to be regarded as brackish.

A total of 34 taxa of zooplankers belonging to six groups were observed during the study period (28 taxa were identified to species) (Table 1). Six groups were cladocerans, copepods, rotifers, mysids, nematods, and fish eggs and larval fishes, respectively. Copepods and rotifers showed the prosperity in species number occurred with 15 species and 7 species, respectively. Four species of cladocerans and two species of mysid were also identified to species. Zooplankton fauna in the study waters has been revealed to be quite different from typical fauna of freshwater lakes which are usually rich in species of cladocerans and rotifers (cf. Hellawell, 1986; Williamson *et al.*, 2002). Poverty in species number and abundance of rotifers is probably due to the coarse mesh size of the net used in the study.

Table 1. Zooplankton distribution at three lakes in Shinpo district, North Korea, 2002.
○: Freshwater spp. △: Brackish spp. □: Marine spp.

Species	Abundange (indiv/m^3)																	
	May									October								
	Homanpo			Hyunkum			Daein			Homanpo			Hyunkum			Daein		
	○	△	□	○	△	□	○	△	□	○	△	□	○	△	□	○	△	□
Nematoda									283									
Cladocera																		
Alona quadrangularis													49					
Alona rectangula													25					
Bosmina longirostris							141			37								
Moina macrocopa																293		
Copepoda																		
Calanoida																		
Acartia iseana		33									10							
Paracalanus indicus			49															
Pseudodiaptomus inopinus		99			110						147			98			62	
Sinocalanus tenellus		280			59,303			424						467			2,774	
Cyclopoida																		
Cyclops vicinus													49			31		
Diacyclops crassicaudis											37							
Encyclops serrulatus					27													
Limnoncaea genuina											37							
Macrocyclops albidus											37							
Oithona nana			33															
Harpacticoida																		
Attheyella dogieli											10							
Attheyella sp.														10				
Canthocamptus mirabilis					165													
Harpacticella panadoxa											737			10				
Moraria poppei																		
Nitocra lacustris											368							
Copepodite		313			3,071			141			1,253			270			3,699	
Copepoda nauplius		1,880			13,626			424			1,363			1,474			5,779	
Mysid																		
Acanthomysis longirostris			66						849									
Proneomysis misakiensis														25				
Rotifera																		
Brachionus calyciflorus	16												25					
Brachonus calyciflorus f. *amphiceros*																15		
Brachonus dimidiatus f. *inermis*																77		
Dipleuchlanis propatula													49					
Monommata grandis																15		
Platyias guadricornis var. *brevispinus*																15		
Schizocerca diversicornis																15		
LARVAE																		
Fish egg							141											
Fish larvae					55													
Aquatic insect larvae													49			46		
Total		2,770			76,329			2,405			4,036			2,599			12,822	

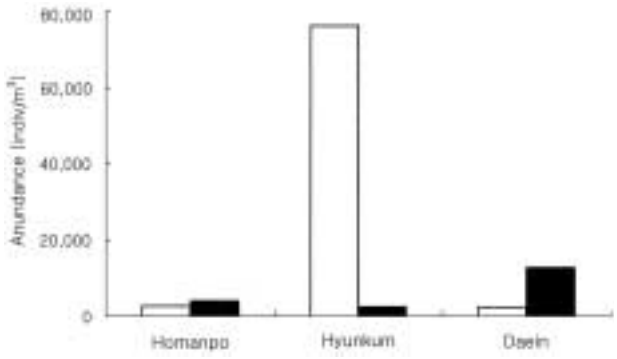

Fig. 3. Variation in zooplankton abundance in three lakes of Shinpo district, North Korea. Open column: May 2002, solid: October, 2002.

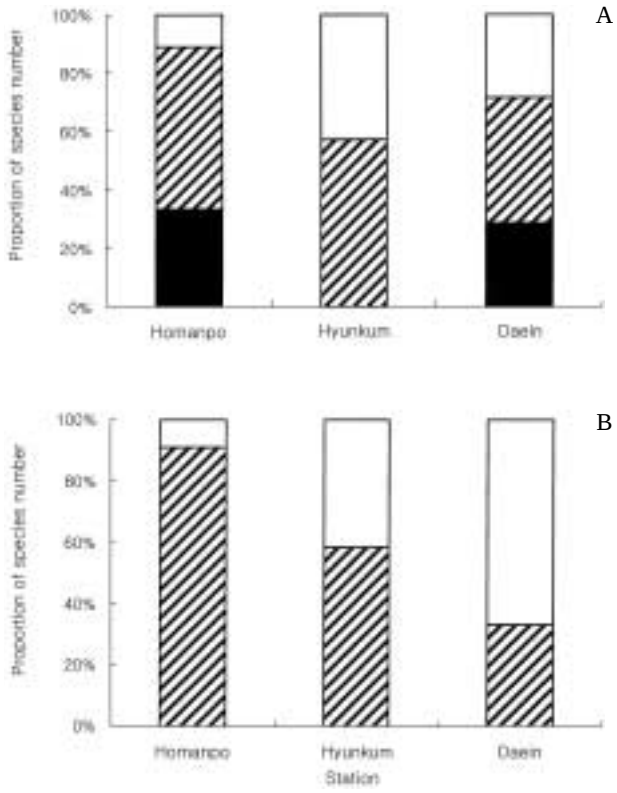

Fig. 4. Percent composition of species number occurred in three lakes of Shinpo district, North Korea. A. May 2002, B. October 2002. Open column: freshwater species, hatched column: brackish species, solid column: marine species.

Then, rotifer's prosperity should be underestimated in the study.

No distinct difference was observed in the number of species occurred (7-9 species) among three lakes in May (Fig. 2). Possibly due to heavy rain falls during the summer, three lakes showed the prosperity in species number in October (more than ten species).

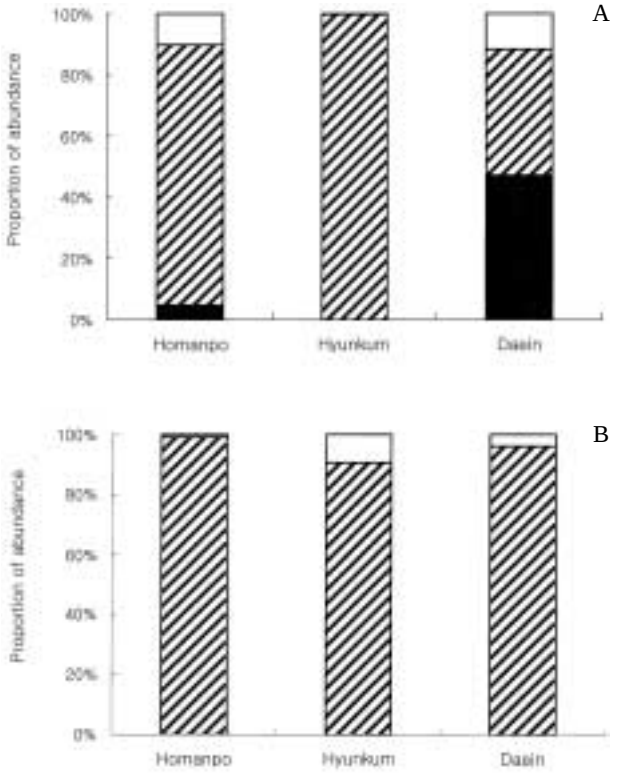

Fig. 5. Percent composition of zooplankton abundance in three lakes of Shinpo district, North Korea. A. May 2002, B. October 2002. Open column: freshwater species, hatched column: brackish species, solid column: marine species.

Lake Hyunkum was observed to be exploded by brackish water copepod, *Sinocalanus tenellus* (59,000 indiv./m^3) in May, when zooplankton abundance was 76,000 indiv./m^3 (Fig. 3). In October, *S. tenellus* occurred abundantly again at lake Daein. This kind of explosion of *S. tenellus* has been well documented by previous studies in a brackish pond, Japan (Hada *et al.*, 1986; Kimoto *et al.*, 1986a, b). Due to the cannibalism in *S. tenellus*, this species is known to be able to establish a huge population even without any prey organisms (Hada, 1985).

Fig. 4 indicated the percentage composition of species number of each group belonging to freshwater zooplankton, brackish and marine ones at each station, respectively. Due to the occurrence

of nematods and a marine mysid, *Acanthomysis longirostris*, the proportion of marine species was recorded to be high at lakes Homanpo and Daein in May (Fig. 4A). Brackish copepods of *Pseudodiaptomus inopinus* and *Sinocalanus tenellus* seem to be common species in all lakes of this region. No marine zooplankton was observed in October (Fig. 4B).

Proportion in the abundance of each group belonging to freshwater zooplankton, brackish and marine ones at each station showed that freshwater ones occupied less than 10% of total zooplankton abundance in three lakes during the study period (Fig. 5). The proportion of brackish and marine zooplankton also exceeded 99% of total zooplankton abundance at lake Hyunkum in May. We considered copepodite and copepod nauplius as brackish animals due to being comparably higher proportion of brackish adult copepod. Unless these proportions were brackish zooplankters' one, the proportion of freshwater zooplankton might be underestimated.

We conclude that seawater input is more active in the spring in lakes of Shinpo district, North Korea. Lake Hyunkum showed the typical characteristics of brackish zooplankton fauna which was dominated by single species of brackish copepod, *Sinocalanus tenellus* (cf. Hada *et al.*, 1986). Shinpo district is now developing with the industrialization of constructing new roads and building two light-water reactors beside lake Hyunkum. Although there is no plan to connect the waterway between the coast and lake, long-term monitoring appears to be needed to provide basic data to protect brackish lakes in Shinpo district, North Korea.

ABSTRACT

Three lakes (lake Homanpo, Hyunkum and Daein) were revealed to be brackish by the results of zooplankton fauna and salinities (2.8 ppt and 0.8 at lake Hyunkum in May and October 2002, and 1.5 and 0.5 at the Daein) in Shinpo district, North Korea. Among 34 taxa of zooplankton occurred, copepods and rotifers showed the prosperity in species number with 15 species and 7 species, respectively. Twenty four taxa of freshwater animals, six brackish ones and four marine ones were found. Brackish copepods, *Pseudodiaptomus inopinus* and *Sinocalanus tenellus*, were found in all lakes. More than 90% of zooplankton abundances consisted of brackish and marine species in three lakes. The outburst of *S. tenellus* was observed (59,000 indiv./m^3) at lake Hyunkum in May, when the proportion of brackish and marine zooplankton exceeded 99% of total zooplankton abundance. Long-term monitoring appears to be needed to provide basic data to protect brackish lakes in the study area.

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