Seasonal Change in Abundance of Zooplankton in Kahoku-gata

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Seasonal Change in Abundance of Zooplankton in Kahoku-gata

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河北潟の浮游動物の季節変化

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Abstract

Seasonal changes in the abundance of zooplankters and inorganic factors in Kahoku-gata were studied in 1990 and 1991. Horizontal differences were small in all factors. Dissolved oxygen was usually saturated. The density of chloride ions was below 50 mg/L, which shows that Kahoku-gata was freshwater. Three rotifer species, *Brachionus diversicornis, Brachionus calyciflorus* and *Asplanchna sieboldi* became abundant. Crustaceans included one branchiopod species, *Diaphanosoma brachyurum*, and 9 copepod species. *Eucyclops roseus, Cyclops vicinus, Thermocyclops taihokuensis, Eodiaptomus japonicus* and *Schmackeria inopinus* became abundant. Of all zooplankters, the highest density was attained by *B. diversicornis* in spring and summer. *Brachionus calyciflorus* increased when neither the competitor *B. diversicornis* nor the predator *A. sieboldi* was abundant. *Brachionus calyciflorus* was spined in the presence of *A. sieboldi*. Crustaceans increased in August and September.

Introduction

Kahoku-gata is a shallow lake (maximum depth, 5 m) located near the Sea of Japan (36°36'E, 136°41'N). Partial reclamation from 1963 to 1970 reduced the surface area from 23 to 4 km², and desalination after 1978 reduced the density of chloride ions from 1～14 to below 0.05 g/L. The plankton fauna of the lake was studied before reclamation (1946-1951) by Mashiko (1955), and just after reclamation and before desalination (1972) by Kamijyo *et al.* (1973). Besides, Kawabata and Defaye (1994) described the planktonic copepod fauna from the zooplankton samples collected from 1990 to 1992. However, the ecology of zooplankters after desalination has not been reported.

In the present study, seasonal changes in the abundance of zooplankters were investigated in 1990 and 1991 at pelagic sites in Kahoku-gata. Water temperature, dissolved oxygen and chloride ions were also measured.

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Methods

In 1990, the samples were collected at the three stations shown in Fig. 1 in the mornings of 28 April, 30 May, 7 July, 20 August, 29 September, 28 October and 26 November. In 1991, collection was performed only at the Station 2 near midnight on 19 March, 29 April, 25 May, 25 June, 14 August, 2 and 23 September, 22 October, 16 November and 15 December. Zooplankton was collected by vertical haul from the bottom to the surface with a plankton net; the mesh size and diameter were 180 μm and 29 cm in 1990, and 100 μm and 20 cm in 1991. Collected zooplankton was fixed with Lugol solution. Water was collected near the water surface and near the bottom with a 3-L Van Dorn sampler, and the water temperature was also measured at those sampling stations.

Zooplankton was enumerated for each species under a stereomicroscope. For copepods, cyclopoids and calanoids were distinguished each in nauplii and copepodids. Species were identified for copepodid calanoids and adult female cyclopoids. Dissolved oxygen was measured in 1991 by the Winkler method, and chloride ions were measured in 1990 by titration with silver nitrate.

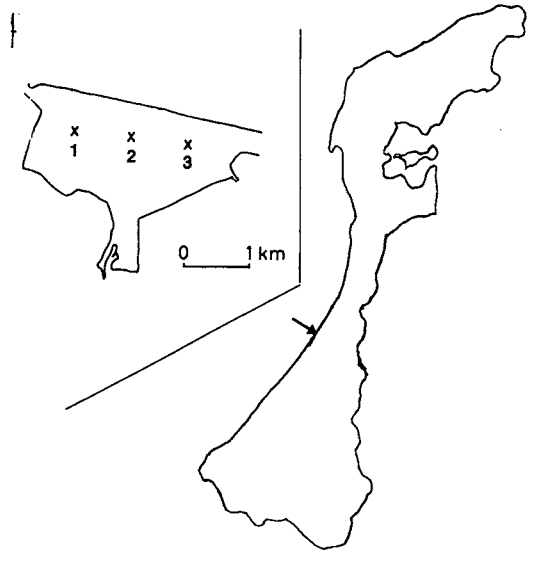

Fig. 1 Map of Ishikawa Prefecture and Kahoku-gata, showing 3 sampling stations.

Results

Water temperature showed similar seasonal change in 1990 and 1991, ranging from 7 to 30°C (Fig. 2). Three stations did not differ in temperature, and the vertical difference increased to 2.6°C only in the summer of 1990. Dissolved oxygen was usually saturated (Fig. 2). However, supersaturation was found near the water surface in the spring of 1991 and at both depths in September 1991. On the contrary, oxygen depletion occurred at both depths in June 1991. The density of

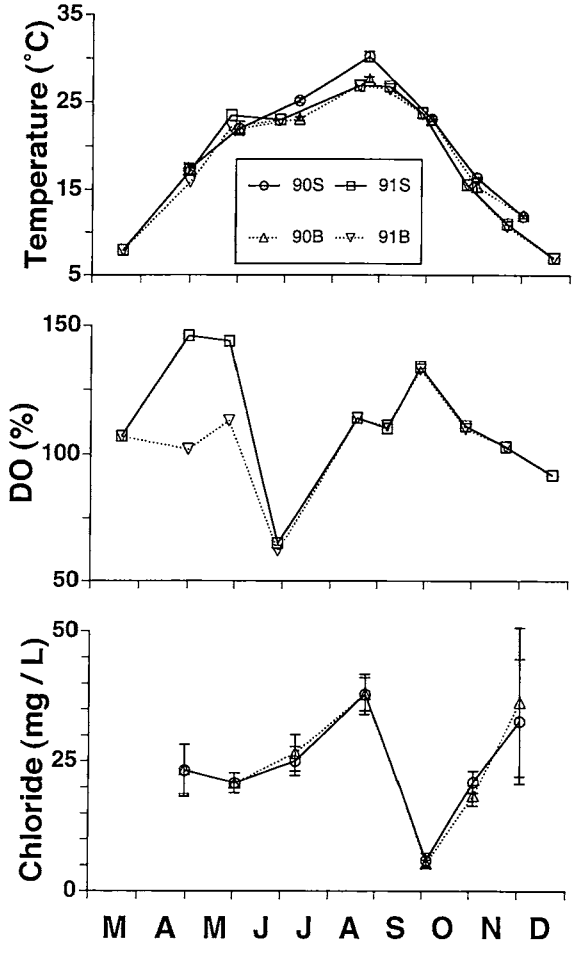

Fig. 2 Seasonal changes in water temperature, saturation of dissolved oxygen, and concentration of chloride ions near the water surface (S) and near the bottom (B) in 1990 and 1991. Mean of 3 stations in 1990 is shown with standard deviation (vertical range).

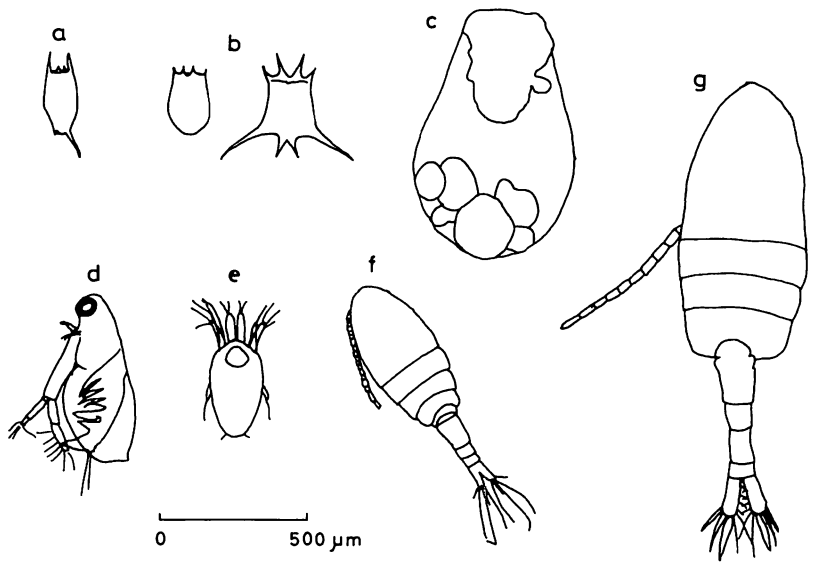

Fig. 3 Illustrations of zooplankters: a, *Brachionus diversicornis*; b, *Brachionus calyciflorus* (unspined and spined forms); c, *Asplanchna sieboldi*; d, *Diaphanosoma brachyurum*; e, naupliar cyclopoid copepod; f, adult female *Thermocyclops crassus*; g, adult female *Schmackeria inopinus*.

chloride ions fluctuated around 25 mg/L, never exceeding 50 mg/L (Fig. 2). Hence, Kahoku-gata was not brackish but freshwater (Horne and Goldman 1994). There was little difference in chloride between depths and among sites except in November 1990, when only Station 1 showed high values. The value did not change from April to July, increased in August, decreased in September, and increased again until November.

Figure 3 shows the illustrations of some zooplankters collected in the present study. Rotifers included *Brachionus diversicornis, Brachionus calyciflorus* and *Asplanchna sieboldi*. *Brachionus calyciflorus* was either spined or not. Among crustacea, *Diaphanosoma brachyurum* was the sole branchiopod species, and 7 cyclopoid and 2 calanoid copepod species were fully described by Kawabata and Defaye (1994). Their *Eucyclops* cf. *serrulatus* was newly described as *Eucyclops roseus* by Ishida (1997).

In 1990, Station 1 differed from the other 2 stations in the abundance of *B. diversicornis* in May and August, and of *B. calyciflorus* in July (Fig. 4). Such difference was not found for the 2 species on the other months or for *A. sieboldi* on any month. The maxi-

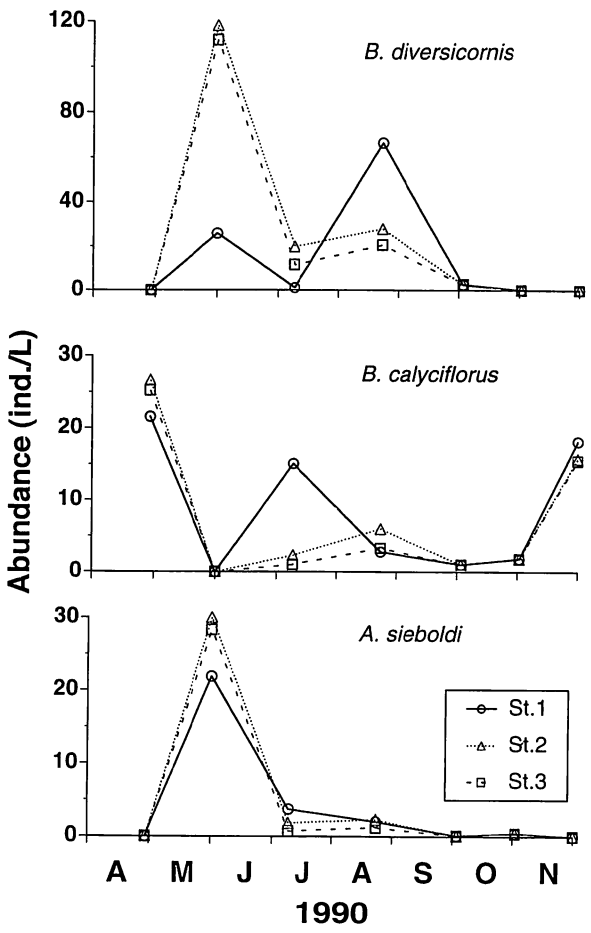

Fig. 4 Seasonal changes in the abundance of *Brachionus diversicornis*, *Brachionus calyciflorus* and *Asplanchna sieboldi* at 3 stations in 1990.

mum density was highest in *B. diversicornis*. The abundance of 2 species of *Brachionus* increased alternately. *Asplanchna sieboldi* increased only in May when *B. calyciflorus* was absent. No individual of *B. calyciflorus* was spined before the propagation of *A. sieboldi* in May, but all were spined after that. In November, spined individuals were again minor.

Crustaceans showed similar abundance at 3 stations in 1990 (Fig. 5). All taxa increased in summer, but the maximum densities were lower than those of rotifers by one order of magnitude. In cyclopoids, copepodids accounted for 36% of the populations in August and 43% in September. Six species of adult female cyclopoids were found in 1990, and *Thermocyclops taihokuensis* was abundant from August to October (Table 1). The proportion of copepodids was lower in calanoids: 10% both in August and September. Of all copepodid calanoids, 64% were *Schmackeria inopinus* in August and 73% were *Eodiaptomus japonicus* in September.

In 1991, the peak abundance of *B. diversicornis* was similar to that in 1990, but occurred only in summer (Fig. 6). The density of *B. calyciflorus* attained the maximum value in spring, and fluctuated thereafter. As in 1990, *B. calyciflorus* did not increase when *B. diversicornis* was abundant. *Asplanchna sieboldi* increased in May and in summer when *B. calyciflorus* was reduced. No individual of *B. calyciflorus* was spined until April, but all were spined from May to early September. The proportion of spined individuals decreased in autumn.

The peaks of calanoids and *D. brachyurum* were found in September 1991, and their densities were comparable to those of rotifers (Fig. 6). Before, at and after the peak of calanoids in late September, the proportion of copepodids was 40, 45 and 41%, respectively; and that of *S. inopinus* was 82, 77 and 35%. Cyclopoids increased in spring and in September; copepodids accounted for 49% of the populations in April and 32% in May, and 73 and 66% in September.

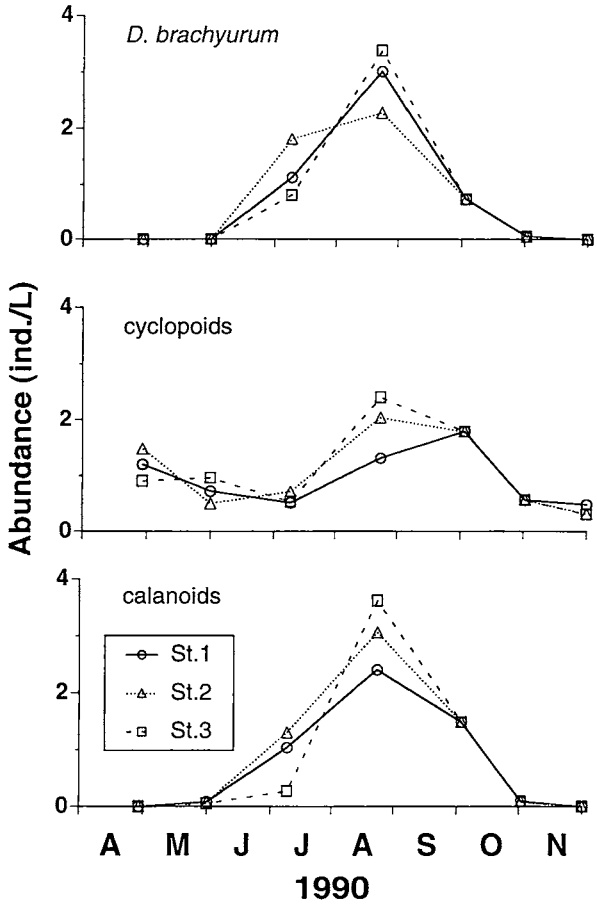

Fig. 5 Seasonal changes in the abundance of *Diaphanosoma brachyurum*, cyclopoids and calanoids at 3 stations in 1990.

Table 1 Number of identified adult female cyclopoids

	1990						1991									
	Apr	May	Jul	Aug	Sep	Oct	Mar	Apr	May	Jun	Aug	1.Sep	23.Sep	Oct	Nov	Dec
Eucyclops roseus	4							22	3	38	3	6				
Paracyclops fimbriatus								1	1							
Cyclops vicinus	1					1	2	4	85							
Acanthocyclops robustus	1								3	4						
Mesocyclops pehpeiensis					1	1			1	10		3				
Thermocyclops crassus			3	1	6	1		1		1	5	3		2		
Thermocyclops taihokuensis			6	15	28	16				13	19	95	104	11		

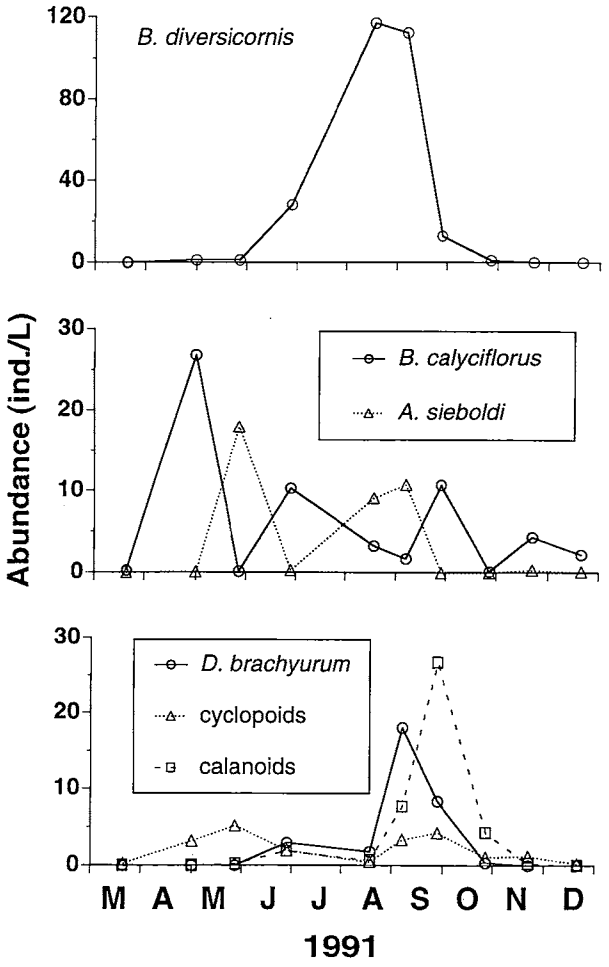

Fig. 6 Seasonal changes in the abundance of *Brachionus diversicornis*, *Brachionus calyciflorus*, *Asplanchna sieboldi*, *Diaphanosoma brachyurum*, cyclopoids and calanoids in 1991.

Seven species of adult female cyclopoids were found in 1991, and *E. roseus* and *Cyclops vicinus* were dominant in spring and *T. taihokuensis* in September (Table 1).

Discussion

Kawabata and Defaye (1994) reported that S. *inopinus* was the sole copepod species surviving partial reclamation and desalination of Kahoku-gata. The other 8 zooplanker species described from Kahoku-gata before reclamation (Mashiko 1955) were not found in the present study at all. After reclamation, only *B. calyciflorus* and *A. sieboldi* survived desalination until the present survey (Kamijyo et al. 1973). Thus disturbance by human activities has completely changed the plankton fauna of Kahoku-gata.

The densities of copepods were higher in 1991 than in 1990 probably because they were collected at night in 1991. Their diel distribution shifts will be reported in a coming paper.

The alternate increase of 2 species of *Brachionus* suggests their competitive interaction. The rises of *A. sieboldi* and *B. calyciflorus* were also alternate, which implies the coupled oscillation of predator and prey. The kairomone released by the predator *Asplanchna* stimulates the oocytes of *B. calyciflorus* to develop into long-spined females, which suffer less predation risk (Gilbert 1999). Also in the present study, *B. calyciflorus* was spined during and just after the propagation of *A. sieboldi*. Further details about their relationship in Kahoku-gata will be reported elsewhere.

Acknowledgments

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