Rep. Res. Edu. Ctr. Inlandwat. Environ., *2* : 25-28 (2004)

Seasonal changes of carbon and nitrogen stable isotope ratios for dominant species: chironomid larvae, phytoplankton, and benthic diatom inhabiting strongly acidic Lake Katanuma

Hideyuki DOI[1], Eisuke KIKUCHI[2], Shigeto TAKAGI[1], and Shuichi SHIKANO[2]

[1] Graduate School of Life Sciences, Tohoku University, Kawauchi, Aoba-ku, Sendai 980-8576

[2] The Center for Northeast Asian Studies, Tohoku University, Kawauchi, Aoba-ku, Sendai 980-8576

ABSTRACT: Lake Katanuma is a volcanic, strongly acidic lake (average pH of 2.2), located in Miyagi prefecture, Japan. Only a few species are found in Katanuma; *Chironomus acerbiphilus* larvae as benthic invertebrate, *Pinnularia braunii as benthic* diatom, and *Chlamydomonas acidophila* as phytoplankton. We tried analyzing seasonal changes of carbon and nitrogen stable isotope ratios for these species in Lake Katanuma. Food source analysis by isotope ratios clearly showed main food source for *Chironomus acerbiphilus* larvae was *P. braunii* (benthic diatom). δ^{1} C values of *P. braunii* varied seasonally, while those of POM (mainly phytoplankton) remained fairly stable. The difference of stable isotope ratios in these organisms are discussed

Key Words: carbon, nitrogen, stable isotope, chironomid larvae, phytoplankton, benthic diatom, Lake Katanuma

Introduction

Several studies have been reported that carbon and nitrogen isotope ratios of plankton are frequently changed seasonally in freshwater ecosystems (e.g. Zohary *et al.* 1994). However, most previous studies of freshwater organisms stable isotopes involved only one or a few field samplings and hence failed to disclose any seasonal variations in δ^{13}C values of organisms in a lake. Lake Katanuma is a volcanic, strongly acidic lake (average pH of 2.2). Only a few species (*C. acerbiphilus* larvae, *P. braunii, and C. acidophila*) are exclusively dominant in Katanuma because of its strong acidity. We tried analyzing seasonal changes of carbon and nitrogen stable isotope ratios for these species in Lake Katanuma. The simple biotic community of the lake could make it possible for an accurate and exact analysis of interrelationships between the isotope ratios of organisms and biotic and abiotic environmental factors.

Materials and Methods

Study Area

Lake Katanuma is located at 38° 44'N, 140° 43'E, with a lake surface area of 0.14 km2, and maximum depth of 20 m. There is no inflowing and outflowing river. Hydrogen sulfide and heat are supplied from the lake bottom. Lake Katanuma is basically a dimictic lake, stratification period is from April to August, and circulation is observed between September and December. Between January and mid-March the lake is almost covered with ice. Zooplankton and nekton have not been observed in Lake Katanuma. While high densities of the *C. acerbiphilus* larvae, *P. Braunii, C. acidophila*, and sulfate oxidizing bacteria were often observed (Doi et al. 2001).

Sampling and sample preparation

C. acerbiphilus larvae and sediment samples were collected at 1, 2, 4, and 10 m depth with an Ekman-Birge grab from April to December in 2000 and 2001. In the laboratory *C. acerbiphilus* larvae were put into filtered lake water for 24 hours to eliminate their gut content. Water samples for POM were collected at 1, 2, 4, and 10 m depth with an Van-Dorn water sampler from April to December in 2000. Water sample were filtered by Whatman GF/F glass filter (precombusted at 500°C for two hours), in order to collect POM samples. P. braunii were extracted from the sediment at 1, 2, and 4 m depth from April to December in 2001 by making use of its phototactic movement (Doi et al. 2001). In order to determine the abundance of P. braunii, Chlorophyll a content of surface sediment (up to 1 cm) were measured by Whitney and Darley method (Whitney et al. 1979). The samples of carbon and nitrogen isotope ratios were measured with mass spectrometer (DELTA plus, Thermoquest Co.) Results are reported in the delta notation (unit:‰). Analysis errors were within ±0.2‰ for δ13C and δ15N.

Results and Discussion

In lake ecosystem, the $\delta^{13}C$ value of phytoplankton have been observed varing seasonally (Zohary *et al.* 1994). However, mean $\delta^{13}C$ values of POM (mainly phytoplankton) in Lake Katanuma varied in a narrow range from −26.4 to −23.7‰, and the seasonal difference of the value were only 2.7‰. This variation was lower than other lakes reported by Zohary *et al.* 1994. Some of reasons of this stability of $\delta^{13}C$ values of POM may be 1) *Chlamydomonas acidophila* are only species as phytoplankton in Lake Katanuma. Therefore , the changes of species composition need not be considered. 2) DIC (dissolved inorganic carbon) to *Chlamydomonas acidophila* was enough, because of the continuous supply of DIC from fumorales in the lake bottom (Hino, Personal Com.). Both $\delta^{13}C$ values and abundance (chlorophyll a in surface sediment) of *P. braunii* in Lake Katanuma varied seasonally, especially at 1 and 4 m depth. And relationships between $\delta^{13}C$ values and abundance (chlorophyll a in surface sediment) of *P. braunii* showed positive significant correlations at 1 and 4 m depth between $\delta^{13}C$ values of *P. braunii* and chlorophyll a in surface sediment, suggesting higher biomass of *P. braunii* corresponded to higher $\delta^{13}C$ values of *P. braunii* at 1 and 4 m depth. In Lake Katanuma the higher biomass of *P. braunii* often forms patches (algal mat) on the sediment surface at the shore (Satake and Saijo 1978). Thicknesses of these mat became sometimes 0.5 – 1.0 mm (Satake and Saijo 1978). Thus *P. braunii* were considered to promote ^{13}C-enrichment in their high density mats because of limitation of supply of DIC.

The mean $\delta^{13}C$ values of POM (mainly phytoplankton) were lower and more stable than those of benthic diatom (*P. braunii*). The difference in mean $\delta^{13}C$ values between phytoplankton and benthic diatom may be explained by the boundary layer effects and higher variability of $\delta^{13}C$ values of the benthic diatom by the heterogeneity of diatom density. *P. braunii* often made high density patch (algal mat) in Lake Katanuma, and the $\delta^{13}C$ of the diatom in the algal mat became much higher values (^{13}C-enrichment) due to the limitation of CO_2 supply.

Seasonal variation of $\delta^{13}C$ values of *C. acerbiphilus* larvae showed the $\delta^{13}C$ values of them in stratification months from April to August are significantly lower than circulation months from October to December at all depths (1, 2, and 4 m) ($P<0.01$, Fisher's PLSD). The differences of $\delta^{13}C$ values suggest that diets of *C. acerbiphilus* larvae are different between stratification and circulation months. This suggests that *C. acerbiphilus* larvae in stratification period may feed on *Chlamydomonas acidophila* and sedimentary organic matter mainly, and *C. acerbiphilus* larvae in circulation period may feed on *P. braunii* mainly. The $\delta^{13}C$ and $\delta^{15}N$ plots of *C. acerbiphilus* larvae, POM, *P. braunii*, marsh plant (*Phragmites australis*), and sediments from April to December in 2000 and 2001 are showed in Fig.1, the most probable food source of *C. acerbiphilus* larvae in Lake Katanuma was concluded to be benthic algae *P. braunii* (Doi *et al.* 2001). But relationship between $\delta^{13}C$ values of *C. acerbiphilus* larvae and *P. braunii* were not correlated significantly (Pearson's correlation coefficient, r=0.001, $P>0.05$, n=36), probably because *C. acerbiphilus* larvae have fairly long generation time (about 1 month) and may feed on *P. braunii* at various sites.

Acknowledgments

We thank Dr. Ito K., Department of Agriculture Tohoku University, for her assistance in the stable isotope analytical facilities as well as to Dr. Aikins S., The Center for Northeast Asian Studies Tohoku University, for correcting the manuscript.

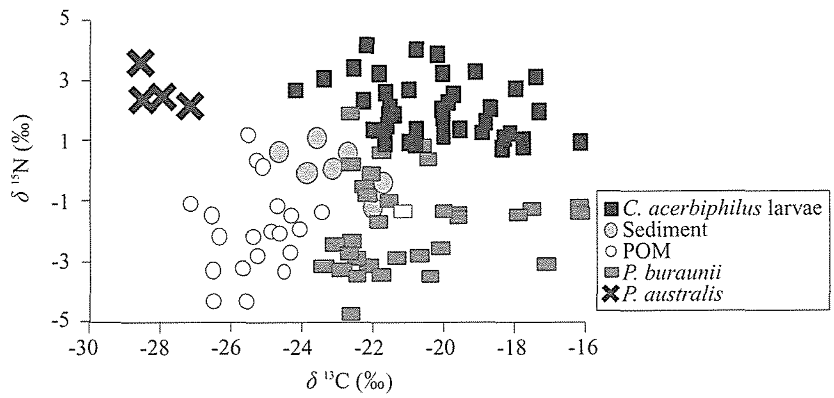

Fig. 1. Mean values of $\delta^{13}C$ and $\delta^{15}N$ plots of *C. acerbiphilus* larvae, sediment, POM, *P. braunii*, and *P. australis* : *C. acerbiphilus* larvae were collected in 2000 and 2001, sediment, POM, and *P. australis* were collected in 2000, and *P. braunii* were collected in 2001.

References

Doi, H., Kikuchi, E., and Shikano, S. (2001) Carbon and nitrogen stable isotope ratios analysis of food sources for *Chironomus acerbiphilus* larvae (Diptera Chrinomidae) in strongly acidic Lake Katanuma. *Radioisotopes*, 50, 601-611.

Satake K, Saijo Y (1978) Mechanism of lamination in bottom sediment of the strongly acid Lake Katanuma. *Arch. Hydrobiol.*, 83, 429-442.

Whitney D. E., Darley W. M. (1979) A method for the determination of chlorophyll a in samples containing degradation products. *Limnol. Oceanogr.*, 24, 183-186.

Zohary T., Erez J., Gophen M., Berman-Frank I., Stiller M. (1994) Seasonality of stable carbon isotopes within the pelagic food web of Lake Kinneret. *Limnol*, *Oceanogr.*, 39,1030-1043.