Rep. Res. Edu. Ctr. Inlandwat. Environ., *2* : 21-24 (2004)

Preliminary studies on carbon and nitrogen stable isotope ratios analysis of food web in Lake Chany of Western Siberia

Eisuke KIKUCHI[1], Hideyuki DOI[2], Shuichi SHIKANO[1], Natalia YURLOVA[3], Elena YADRENKINA[3], Elena ZUYKOVA[3] and Hiroshi OTA[2]

[1] Center for Northeast Asian Studies, Tohoku University
[2] Graduate School of Life Sciences, Tohoku University
[3] Institute of Animal Systematics and Ecology, Siberian Branch of Russian Academy Sciences

ABSTRACT: Lake Chany is an inland moderately saline lake in Western Siberia. It consists of three lakes, Bolshye (Large) Chany, Malye (Small) Chany and Yarkul Pool. Field survey of Lake Chany was carried out at four parts of the lake with different salinity to analyze their food web structures using carbon and nitrogen stable isotope as natural tracers. The intruding river region (St.1) and Malye Chany (St.2) with low salinity (0.9‰), the central part of Bolshye Chany (St.3) with salinity of 5.7‰ and the innermost part of Bolshye Chany (St.4) with the highest salinity of 6.3‰ were selected as study sites. Comparison of the isotope ratios of benthic invertebrate (Chironomidae; Diptera) among the sampling sites showed the lowest $\delta^{13}C$ and $\delta^{15}N$ values at St.1 and the highest values at St.4. The benthic invertebrates at St.3 showed similar $\delta^{13}C$ and $\delta^{15}N$ values to those of St.4 and St.1, respectively. Similar trends but different values of the isotope ratios among the sampling stations were observed in zooplankton, POM and sediment samples, indicating the initial substances of the food chains were different at different parts of the lake.

Key Words: Lake Chany, inland saline lake, food chain, carbon and nitrogen stable isotope ratios

Introduction

Food webs depict energy flow and nutrient cycling pathways in ecosystems. All organisms are included in a food web by trophic connections in ecosystems. Traditionally, most studies of food webs have been based on observations of feeding behavior, gut contents and fecal pellets and growth experiments. However, it is difficult to elucidate the trophic links in ecosystems with only these traditional methods, since many trophic interactions are not visible.

Stable isotope analysis is now widely used as a means of tracing material flow through food chains. The stable isotope ratio of organic carbon has been found to be an excellent tracer to identify the diet of invertebrates, since only minor changes in the carbon isotope ratio occur with each trophic transfer (DeNiro &

Epstein, 1978). On the other hand, nitrogen isotopes are useful in defining trophic levels because ^{15}N is more enriched (3 – 4 ‰) in consumers than in their food (Minagawa & Wada, 1984). Stable isotope ratios have been successfully applied to investigations of energy sources and trophic structure in terrestrial and aquatic ecosystems.

Lake Chany is located in the southern portion of Western Siberia (54°30' – 55°09'N and 76°48' – 78°12' E) at an altitude of 106 m above sea level. The lake is an inland moderately saline lake and mainly consists of two parts, Bolshye (Large) Chany and Malye (Small) Chany. Bolshye Chany is characterized by a very indented shore line with many gulfs, Bays, peninsulas and islands, and consist of several shallow flats. The salinity of the lake differ in different parts of the lake (Zhechnovskaya, 1982). In this study carbon and nitrogen isotope ratios of organisms, POM and sediment were measured at the different parts with different salinities in Lake Chany to obtain the general pictures of the food web structures.

Materials and Methods

Lake Chany, located in the Novosibirsk region between the rivers Ob and Irtish, lies in the Barabinskaya lowland. The lake represents a large (82 km long, 36 km wide) and shallow (average depth; about 2 m) inland saline system, a characteristic of the Western Siberian forest-Steppe. Lake Chany is an enclosed water body, which comprises of three lakes, Bolshye (Large) Chany, Malye (Small) Chany and Yarkul Pool. Small channels connect these lakes. Bolshye Chany is consisted of three shallow flats, Chinyaikhinskii Pool, Tagano-Kazantsevskii Pool and Yarkov Pool (Fig. 1). Two main inflowing rivers, rivers Kargat and Chulym, flow into Malye Chany. Salinity gradually increases from the rivers to innermost parts of Bolshye Chany (Yarkov Pool). In this study, the estuarine part of Kargat river (St.1), Malye Chany (St.2), the central part of Bolshye Chany (Tagano-Kazantsevskii Pool; St.3) and the innermost part of Bolshye Chany (Yarkov Pool; St.4) were selected as study sites (Fig. 1). Several properties of water at sampling sites are shown in Table 1. The sampling were carried out in August 2001.

For POM samples the surface water was filtered by a Watman GF/F glass fiber filter (precombusted at 500° Cfor 2 h) to collect POM on the filter. Sediment samples were collected at each sampling station using Petersen grab. Benthic invertebrates were sorted from the sediments and put into water for more than 12h

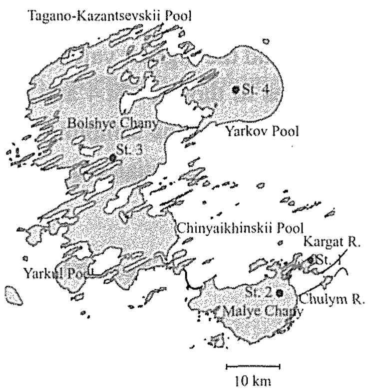

Fig. 1. Sampling locaitons in Lake Chany (Sts. 1-4).

Table 1. Some properties of water at each sampling site.

Site	depth (m)	Salinity (‰)	Chl. *a* (μg/l)	DO (mg/l)	pH	Ilonic composition (g/l)					
						Na	K	Mg	Ca	Cl	SO4
St. 1	1.0	0.9	69.4	9.2	8.44	0.65	0.04	0.11	0.15	0.38	0.27
St. 2	2.2	0.8	28.8	8.6	8.81	0.25	0.01	0.09	0.06	0.28	0.16
St. 3	2.0	5.7	5.7	10.2	8.91	1.59	0.03	0.40	0.05	1.79	0.79
St. 4	5.5	6.3	5.7	9.6	8.80	2.56	0.04	0.63	0.04	3.04	1.09

to clear their guts. Zooplankton was collected with nets and sorted under stereo microscope. Fishes were collected using a gill net. Then all samples were dried in a 60° C oven and kept frozen for later analyses. Whole body for benthic invertebrates and zooplankton and muscle tissue for fish were used for the measurement of isotope ratios. The sediment samples were treated with 1.0 N HCl to remove bicarbonate before the measurement. No animals could be collected from St. 2 in this survey.

Stable isotope ratios of dried samples were measured with mass spectrometer (DELTA plus, Thermoquest Ltd.). Isotopic value is expressed in the delta (δ) notation, defined as per mil (‰) deviation from the isotope standard PDB (Pee dee Belemnite) carbonate or atmospheric N_2.

Results and Discussion

$\delta^{13}C$ and $\delta^{15}N$ plots of all the organisms, POM and sediments were showed in Fig. 2. In St. 1 (the Kargat River), the isotope ratios of 4 zooplankton species, *Scapholeberis mucronata*, *Eudiaptomus graciloides*, *Daphnia longispina* and *Leptodora kindtii*, and some Chironomidae species were measured. All the zooplankton species have fairly similar $\delta^{13}C$ value (−29.4 to −27.7‰), but variable $\delta^{15}N$ values (3.5 to 9.2‰) in St. 1. The similar $\delta^{13}C$ values of zooplankton seemed to indicate that they were on a food chain originating from the same initial food substance (primary producer), since only minor changes in the carbon isotope ratio occur with each trophic transfer. While ^{15}N is more considerably enriched (3−4‰) in consumers than in their food. Therefore, the lowest $\delta^{15}N$ value (3.5‰) of *Scapholeberis mucronata* showed its lowest trophic levels among the zooplankton species. *Leptodora kindtii*, which is known as a carnivorous species, had the highest $\delta^{15}N$ value (9.2‰). POM in St. 1 also showed fairly similar $\delta^{13}C$ value (−26.6‰) to zooplankton species, and lower $\delta^{15}N$ value (3.1‰). This suggests the food chain of zooplankton in St. 1 started from phytoplankton in POM. On the other hand, benthic invertebrates (Chironomidae) collected from St. 1 showed much lower $\delta^{13}C$ value (−30.8 to −29.4‰) than sediment (−24.9‰) which they fed on. They might have assimilated portions with lower $\delta^{13}C$ value selectively from bulk sedimentary organic matter.

At St. 3 we collected samples of some fish species including *Cyprinus carpio*, *Carassius auratus gibelio*, *Rutilus rutilus lacustris*, *Perca fluviatilis*, *Leuciscus idus* and *Stizostedion lucioperca*. All the fish species collected at St. 3 had similar $\delta^{13}C$ value (−23.9 to −22.0‰), but variable $\delta^{15}N$ values (9.4 to 14.4‰), suggesting that each fish species is located on same food chain but at different food levels. POM in St. 3 had similar $\delta^{13}C$ value (−22.4‰) to the fish species, and lower $\delta^{15}N$ value (5.0 ‰). This suggests the food chain of fish species in St. 3 started also

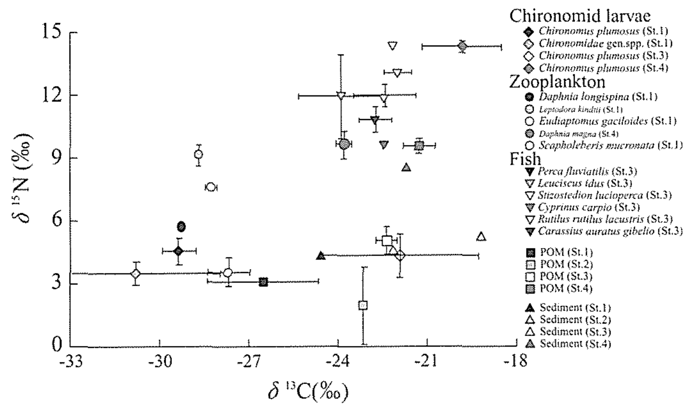

Fig. 2. Two-demensional isotope plots of organisms, POM and sediments in Lake Chany. Bars indicate ± SD.

from POM (phytoplankton). Therefore two fish species, *C. carpio* and *C. auratus*, with lower $\delta^{15}N$ value of about 10‰ would be considered to feed on POM (phytoplankton) and/or zooplankton, if we could suppose the presence of zooplankton which feed on POM and the enrichment of $\delta^{15}N$ with 3 – 4‰ during a single feeding process. *P. fluviatilis* and *S. lucioperca* with $\delta^{15}N$ value more than 13‰ may be carnivorous (fish feeders).

Benthic invertebrate *Chironomus plumosus* was collected from all sampling sites except for St. 2. and its isotope ratios have a considerable difference among the sampling sites. *C. plumosus* ($\delta^{13}C$ –29.4‰; $\delta^{15}N$ 4.5‰) at St. 1 had lower $\delta^{13}C$ value and $\delta^{15}N$ value than those ($\delta^{13}C$ – 19.9‰; $\delta^{15}N$ 14.4‰) at St. 4, and *C. plumosus* ($\delta^{13}C$ –21.9‰; $\delta^{15}N$ 4.3‰) at St. 3 showed similar $\delta^{13}C$ and $\delta^{15}N$ value to St. 4 and St. 1, respectively. As compared to isotope rarios of zooplankton of same genes between St. 1 and St. 4, *Daphnia longispina* ($\delta^{13}C$ –29.4‰; $\delta^{15}N$ 5.7‰) at St. 1 showed lower $\delta^{13}C$ and $\delta^{15}N$ values than *Daphnia magna* ($\delta^{13}C$ –23.8‰; $\delta^{15}N$ 9.5‰) at St. 4. Similar trends of the isotope ratios among the sampling stations were observed in POM and sediment samples. POM and Sediment had lower $\delta^{13}C$ value of –26.6 and –24.9 ‰ at St. 1, and higher $\delta^{15}N$ value of 9.6 and 10.1‰ at St. 4, respectively. While Sts. 2, 3 and 4 showed similar $\delta^{13}C$ value of POM (–23.1 to –21.3‰) and sediment (–22.0 to –19.2‰), and Sts. 1, 2 and 3 showed similar $\delta^{15}N$ value of POM (1.9 to 5.0‰) and sediment (4.8 to 5.2‰). Thus, both $\delta^{13}C$ and $\delta^{15}N$ values of organisms, POM and sediment tended to increase from the River Kargat (St. 1) to inner part of Bolshye Chany (St. 4; Yarkov Pool). In general, phytoplankton is considered to be main producer, a base of food chain in aquatic ecosystems and isotope values of phytoplankton seems to be reflected to those of POM, since large part of POM organic matter may be originated from phytoplankton. Consequently, the differences in the isotope values of phytoplankton (POM) are suggested to cause the isotope difference of organisms and sediment at different parts of Lake Chany through food chain and sedimentation.

References

DeNiro, M.J. and Epstein, S. (1978) Influence of diet on the distribution of carbon isotopes in animals. *Geochim. Cosmochim. Acta*, **42**: 495-506.

Minagawa, S. and Wada, E. (1984) Stepwise enrichment of ^{15}N along food chains: Further evidence and the relation between $\delta^{15}N$ and animal age. *Geochim. Cosmochim. Acta*, **48**: 1135-1140.

Zhechnovskaya L.Ph. (1982). The feature of Chany Lake hydrochemistry. p. 198-215. In: The fluctuated Chany Lake. 2nd ed. Leningrad, Nauka. 304 p. (In Russian).