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# Population dynamics of epiphytic chironomid communities in the aquatic macrophyte zones of eutrophic Lakes Suwa and Kitaura

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**ABSTRACT:** We studied the population dynamics of epiphytic chironomid larvae in the vegetated areas of Lakes Suwa and Kitaura. We quantitatively collected chironomid larvae from samples of the 4 species of angiosperms present in the lakes: the emergent plants *Phragmites australis* (a reed) and *Zizania latifolia*; the floating plant *Nymphoides peltata*; and the submerged plant *Potamogeton malaianus*. Collections were made from all 4 plant zones in Lake Suwa from April 2000 to November 2000 and from the reed zone in Lake Kitaura from April 2000 to March 2001. In both lakes the most abundant chironomid larvae on the reed stems from late May to September were Chironominae (especially, *Dicrotendipes pelochloris* and *Glyptotendipes tokunagai*). On the leaves of submerged and floating plants in Lake Suwa, Orthocladinae larvae (especially, *Cricotopus trifasciatus*) dominated during the sampling period.

On the reed stems in Lake Suwa, mean larval density was 0.4 ind $cm^{-2}$ and biomass of epiphytic chironomids was 12.9 $\mu g\ cm^{-2}$; these values were 23% and 22%, respectively, of those in Lake Kitaura. The differences in chironomid abundance observed in the lakes seemed to be caused by differences in food availability (i.e., abundance of algae attached to reed stems).

The average of diversity index ($1/\lambda$, $\lambda$: Simpson's index) of chironomid larvae on each plant was 2.7-3.3 on reed and *Z. latifolia*, 1.8 on *N. peltata* and 1.8 on *P. malaianus* from June to August. The differences in diversity index may be correlated with the conditions of DO concentration during this period.

**Key words:** epiphytic chironomid, Lake Suwa, Lake Kitaura

## Introduction

Chironomid (midge) larvae, which live on bottom sediments, cobble surfaces, and hydrophytes, feed on settling organic matter or on algae attached to substrates. Predators such as fishes and arthropods eat the larvae and pupae. Thus, chironomids play an important role in the material cycle in aquatic ecosystems. However, information on the epiphytic chironomid communities that inhabit the aquatic macrophyte zone in lakes is scarce compared with that on large midges in the profundal zone, because of the taxonomic difficulties associated with small larvae. Our aim was to clarify the species compositions of epiphytic chironomids in the hydrophyte zones of Lakes Suwa and Kitaura, as well as the seasonal fluctuations of larval density and biomass, and to analyze factors that may affect these dynamics.

## Materials and Methods

Lakes Suwa and Kitaura are shallow eutrophic lakes. Lake Suwa is located in the center of Honshu, Japan. Its surface area is 13.3 $km^2$. It has a maximum depth of about 6.8 m and a mean depth of 4 m. Lake Kitaura is situated on the eastern side of Lake Kasumigaura (Nishi-ura) in the northeastern part of the Kanto Plain, central Japan. This lake has a surface area of 35.5 $km^2$, a maximum depth of 7.5 m, and a mean depth of 4 m.

Chironomid larvae were quantitatively collected from samples of the 4 species of aquatic plants that occur in the lakes: the emergent plants *Phragmites australis* (a reed) and *Zizania latifolia*; the floating plant *Nymphoides peltata*; and the submerged plant *Potamogeton malaianus*. Collections were made at Lake Suwa from April 2000 to November 2000 and at Lake Kitaura from April 2000 to March 2001. We collected epiphytic midges in the reed and *Z. latifolia* zones (St. 5), *N. peltata* zone (St. 4), and *P. malaianus* zone (St. 2) at Lake Suwa, and we collected at 2 points in the reed zone at Lake Kitaura (St. 6 and St. 9).

We used two methods provided by Sakuma et al. (in press) for sampling plants. Aquatic plants other than reeds were sampled by the 'picking up' method, and *P. australis* was sampled by the 'covering method'. In the laboratory, matter attached to the plants and containing chironomid larvae was removed from the plant surfaces with a toothbrush and suspended in tap water. About 1/10 of the suspended water was subjected to measurements for Chlorophyll a (Chl-a) and seston (SS). The residual water (about 9/10) was sieved through a 40-μm-mesh net, and the residual matter with the chironomid larvae on the mesh was preserved with 70% ethanol in a glass vial until sorting. Chironomid larvae were picked out under stereoscopic magnification ($\times$ 10 – 50) with a fine dissecting needle. After preparation of slide-mounted larval specimens, the chironomid larvae were identified under a $\times$ 150 – 600 phase-contrast microscope to the generic level by using the key provided by Wiederholm (1983). Identification of these larvae was later confirmed by examination of adults obtained from the same batch of aquatic plant samples. Each larval dry weight was estimated by a body length - weight equation (Smit et al., 1993).

## Results

### Lake Suwa (St. 5, St. 4, and St. 2)

In the emergent reed zone (St. 5), the mean concentration of Chl-a of matter attached to the reed stem surfaces was 4.6 μg $cm^{-2}$. The maximum value was observed in spring. Dissolved oxygen (DO) concentration ranged from 0.3 and 9 mg $L^{-1}$ during the sampling period. The lowest DO concentrations (< 2 mg $L^{-1}$) were observed in May to September. Mean density and biomass of epiphytic chironomid larvae on reed surfaces were 0.4 ind $cm^{-2}$ and 12.9 μg DW $cm^{-2}$ respectively. A total of 15 taxa of chironomids were found on the reed stems. Orthocladinae (especially Orthocladius spp.) dominated from April to early May, and Chironominae (e.g., Dicrotendipes pelochloris, Glyptotendipes tokunagai) appeared from late May to September. Chironomus sp. larvae were dominant when the DO concentration decreased to less than 0.5 mg $L^{-1}$. The maximum density of larvae was observed in June. In late April and early August, the larval biomass was high, although the density was maintained at a low level. The mean of diversity index ($1/\lambda$, $\lambda$: Simpson's index ) was 2.2 during the investigation period. The index was on average 3.3 in June - August.

In the zone of the emergent plant *Z. latifolia* (St. 5), the mean amount of Chl-a on the plant surfaces was 2.9 μg $cm^{-2}$. The DO concentration ranged from 0.3 to 9 mg $L^{-1}$. The mean density of chironomid larvae on the surfaces was 0.2 ind $cm^{-2}$, and the mean biomass was 3.73 μg DW $cm^{-2}$. On this plant, fewer chironomid larvae were captured after mid-August. A total of 14 taxa of larvae were found on this hydrophyte. Chironominae dominated from late May to August. The mean of diversity index was 2.2 during the investigation period. The index was on average 2.7 in June - August.

In the zone of the floating plant *N. peltata* (St. 4), the DO concentration ranged from 1.4 to 12 mg $L^{-1}$. Lower DO concentrations (< 2 mg $L^{-1}$ ) were observed from early June to early August. The mean amounts of Chl-a on the leaves and stalks of *N. peltata* were 0.6 and 3.6 μg $cm^{-2}$, respectively. A total of 9 taxa and 12 taxa of chironomid larvae were present on the leaves and stalks of *N. peltata*, respectively. On the leaves and stalks, Orthocladinae, especially *Cricotopus trifasciatus*., dominated through the investigation period. The mean densities of the midges on the stalks and leaves were 0.2 ind $cm^{-2}$ and 0.04 ind $cm^{-2}$, respectively. The mean biomasses were 1.65 μg DW $cm^{-2}$ on the stalks and 0.85 μg DW $cm^{-2}$ on the leaves. On the stalks, the peak density and peak biomass of chironomid larvae were observed in early July. The mean of diversity index was 2.0 during the investigation period. The index was on average 1.8 in June - August.

In the zone of the submerged plant *P. malaianus* (St. 4), the mean amount of Chl-a on the plants was 3.6 μg $cm^{-2}$. The DO concentration ranged from 4 to 12 mg $L^{-1}$ and did not drop below 3 mg $L^{-1}$ during summer. A total of 14 taxa of chironomid larvae appeared on *P. malaianus*. Orthocladinae dominated through most of the study period. The mean larval density on *P. malaianus* was 1.5 ind $cm^{-2}$. The mean biomass was 16.6 μg DW $cm^{-2}$. The density and biomass of chironomid larvae had 2 peaks, at the end of June and in early August. The mean of diversity index was 2.0 during the investigation period. The index was on average 1.8 in June - August.

### Lake Kitaura

The mean concentration of Chl-a in matter attached to the reed surfaces was 15.1 μg $cm^{-2}$ at St. 6 and 14.8 μg $cm^{-2}$ at St. 9 in Lake Kitaura. In the reed zones of both stations, DO concentrations were maintained between 3.5 and 13 mg $L^{-1}$ through the year, and did not drop below 3 mg $L^{-1}$ during summer. A total of 14 taxa and 13 taxa of chironomid larvae were found on the reed stems at St. 6 and St. 9, respectively, through the investigation period. *Hydrobaenus* sp. and some genus of the Orthocladinae group dominated in April and May and after November, and *D. pelochloris* and *G. tokunagai* dominated from June to October at both points. The mean chironomid larval density and biomass on the reed surfaces were 1.0 ind $cm^{-2}$ and 35.2 μg DW $cm^{-2}$ at St. 6, and 2.5 ind $cm^{-2}$ and 82.1 μg DW $cm^{-2}$ at St. 9, respectively. At both stations, 2 major peaks of density and biomass were observed: from mid-May to mid-June and in early August. In addition, at St. 9 temporary peaks of these parameters were found in April owing to a massive hatching of young instar larvae of *Hydrobaenus*.

## Discussion

### Factors affecting the density and biomass of epiphytic chironomid larvae on reeds in Lakes Suwa and Kitaura

On the reed stems in Lake Suwa, the mean larval density was 0.4 ind $cm^{-2}$ and the biomass of epiphytic chironomids was 12.9 μg $cm^{-2}$; these values were 23% and 22%, respectively, of those at Lake Kitaura. The Chl-a content of the algae attached to the reed stems in Lake Suwa was on average 30% lower than in Lake Kitaura. The amount of Chl-a on the stems can be considered to represent the abundance of the attached algae (mainly diatoms), which are the main food sources of epiphytic chironomid larvae (Tokeshi, 1986; Botts and Cowell, 1993; Dvorak, 1996). Therefore, the differences in chironomid abundance observed in the lakes seemed to be caused by the differences in food availability (i.e., the abundance of algae attached to the reed stems).

### Factors affecting the diversity of epiphytic chironomids in the aquatic macrophyte zones of Lake Suwa

We obtained 13-15 taxa of epiphytic midge larvae in the emergent plant zone (reed and Z. latifolia), 9-12 taxa in the floating plant zone (N. peltata), and 13 taxa in the submerged plant zone (P. malaianus) of Lake Suwa. However, the average of diversity index (1/λ) of chironomid larvae on each plant was 2.7-3.3 on reed and Z. latifolia, 1.8 on N. peltata and 1.8 on P. malaianus from June to August. The differences in diversity index may be correlated with the conditions of DO concentration during this period. In the emergent plant zone, where the DO concentration became less than 2 mg $L^{-1}$ between May and September, Chironominae larvae such as the Chironomus sp. G. tokunagai, and D. pelochloris dominated during this period, whereas small Orthocladinae larvae such as Orthocladius spp. were dominant outside this period, i.e, from April to early May and after October. Chironominae larvae can tolerate oxygen-depleted conditions, but Orthocladinae larvae, with the exception of the large Propsilocerus akamusi, have no tolerance to DO deficiency (Kondo et al., 2001). Thus, the small Orthocladinae larvae found in this study seemed to avoid the DO-depleted emergent macrophyte zone in summer. Sakuma and Hanazato (2001) pointed out that environmental factors, especially DO concentration, were heterogeneous in the vegetated area of Lake Suwa, and that the heterogeneity of DO might be controlled by macrophyte growth and by the abundance of SS. In addition, they suggested that heterogeneity could be important in determining the distribution of organisms in the hydrophyte zones of the lake. Our results substantiate the above suggestion in the case of the epiphytic chironomid community. Our results also suggest that the occurrence of oxygen-depleted conditions, which are disadvantageous to some aquatic macroinvertebrates during summer, helps to maintain the high species diversity of epiphytic midges in the emergent plant zone of this lake.

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## References

Botts, P.S. and Cowell, B.C. (1993) Feeding electivity of two epiphytic chironomids in a subtropical lake. Oecologia, 89: 331-337.

Dvorak, J. (1996) An example of relationships between macrophytes, macroinvertebrates and their food resources in a shallow eutrophic lake. Hydrobiologia, 339: 27-36.

Kondo, S., Hirabayashi, K., Iwakuma, T. and Ueno, R. (ed.) (2001) The world of the Chironomid. Baifukan, Tokyo, Japan (in Japanese).

Sakuma, M. and Hanazato, T. (2001) Heterogeneous distribution of environmental factors and zooplankton in a vegetation area of a eutrophic lake. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie, 27: 4053-4056.

Sakuma, M., Hanazato, T., Nakazato, R. and Haga, H. (2002) Methods for quantitative sampling of epiphytic microinvertebrates in lake vegetation. Limnology, (in press).

Smit, H., Dudok van Heel, E. and Wiersma, S. (1993) Biovolume as a tool in biomass determination of Oligochaeta and Chironomidae. Freshwater Biology, 29: 37-46

Tokeshi, M. (1986) Population dynamics, life histories and species richness in an epiphytic chironomid community. Freshwater Biology, 16: 431-441

Widerholm, T. (ed.) (1983) Chironomidae of the Holarctic region. Keys and diagnoses. Part1 - Larva. Ent. Scand. Suppl., 19: 1-457.