SAMPLING FREQUENCY REQUIRED FOR CHIRONOMID COMMUNITY RESOLUTION IN URBAN LAKES WITH CONTRASTING TROPHIC STATES.

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With 2 Tables and 3 Figures

ABSTRACT: We found that four 10-minute samples of chironomid surface floating pupal exuviae per season were sufficient to characterize 91-100% of the abundant taxa in chironomid communities of urban lakes with contrasting trophic states (mean total epilimnetic phosphorus to mean lake depth [mld] of 1.1 – 133 mg/L/m). Generic richness decreased with increasing total mean phosphorus to mld.

RESUMO: Confirmamosque por estação quatro amostragens de exúvias pupais de quironomídeos, com a duração de 10 minutos, são suficientes para caracterizar 91 a 100% da abundância em taxa destas comunidades em lagos urbanos com diferentes estados tróficos (razão entre o fósforo epilimnético total e a profundidade do lago de 1.1-133 mg/L/m). A riqueza especifica decresceu relativamente ao incremento em fósforo total e da profundidade.

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INTRODUCTION

There is long history of using chironomids to assess lake water quality in Europe, starting with THIENEMANN in 1910 and followed by BRUNDIN (1966), SAETHER (1979) and WIEDERHOLM (1978) among others. Throughout the 20th century, a model of indicator species for lake trophic states has been developed (LINDEGAARD 1995; SAETHER 1979). In particular, SAETHER (1979) and WIEDERHOLM (1978) found chironomid communities to be related to the total mean epilimnetic phosphorus to mean lake depth ratio. This model has not been applied in the United States, particularly in urban areas of Minnesota.

We wanted to determine a relatively fast, inexpensive and efficient way to monitor the response of biota to water quality in lakes of the Twin Cities Metropolitan Area (TCMA) of Minnesota, USA to be used by local lake managers. To determine lake trophic status using chironomids, we first needed to determine the sampling effort required to resolve the chironomid community composition. Therefore, the objective of this study was to determine the sampling frequency required to collect the abundant taxa in urban lakes that can be used as indicators in a lake trophic model. We assessed chironomid communities TCMA lakes using surface floating pupal exuviae (SFPE) since this method takes one-third the time to process than do chironomid larvae and allows for better taxonomic resolution (Ferrington *et al.* 1991).

MATERIALS AND METHODS

In the TCMA there are over 947 lakes. These lakes were formed as the receding glaciers scoured the earth's surface and subsequently melted after the last ice age. The lakes are a valuable local resource for recreation, ecological habitat and the water supply system. The lakes in the TCMA span a gradient of mesotrophic to hypereutrophic, and we chose four mesotrophic lakes, eight eutrophic lakes and four hypereutrophic lakes for a total of 16 lakes (Table 1). We selected lakes (Fig. 1) based on the following criteria: 1) they do not have a known pollutant source other than organic enrichment, 2) they have boat access, 3) 40-80% of the surrounding land use is residential, 4) they are generally round in shape so that the lake has only one bay and consistent trophic state and pupal exuviae collect on the downwind end of the lake, 5) they are the same hydrologic type.

We collected Chironomidae SFPE (FERRINGTON *et al.* 1991) monthly during the ice-free period of 2005 (April to November). Our method consisted of dipping a white pan into the water on the downwind shore of the lake to collect SFPE. The contents of the pan were poured through a 125 micron aperture sieve. This technique was repeated for 10 minutes and the sample was washed into a jar with 80% ethanol field preservative.

Overall sampling consisted of 128 total samples (8 dates/lake x 16 lakes x 1 sample/lake/date), collected over 2-3 consecutive days during the third week of each month.

After each monthly sample session, the SFPE samples were processed the in the lab. A 300 count sub sample of SFPE was randomly picked under 10x magnification from a Syracuse dish and into a vial of 70% ethanol. Samples collected in November did not contain any SFPE and were omitted from the analysis. SFPE were slide-mounted under 5-10x magnification using Euparal® mounting medium and identified to genus following COFFMAN & FERRINGTON (1996) and WIEDERHOLM (1986).

The data were analyzed by determining the number of genera and the proportion of total generic richness detected each month for each lake. The maximum detection efficiency was the highest proportion of total generic richness detected for each lake and what month it occurred. Each permutation of the proportion of total generic richness for 2 months, 3 months and 4 months was also calculated for each lake and again the maximum detection efficiency was the combination with the highest proportion of total generic richness. Next, the generic richness for each lake was correlated to phosphorus to mean lake depth by linear regression.

TABLE 1. Characteristics for the 16 study lakes. Lakes are sorted by mean P/mean depth.

	Mean P/ Mean Depth	Mean P (µg/L)	Depth (m) Mean	Depth (m) Max	Surface Area (Ha)	Secchi Depth (m)	Carlson Index	Generic Richness
Elmo	1,12	15	13,4	41,8	83,4	4,3	43 - M	35
Christmas	1,29	13	10,1	26,5	104	5,7	41 - M	31
Square	1,33	12	9	20,7	78,9	6,4	40 - M	32
Little Long	1,8	11	6,1	23,2	32,4	5	39 - M	26
Calhoun	2,5	27	10,6	27,4	170,4	3	54 - E	31
Harriet	3,28	29	8,7	25	142,9	3,2	54 - E	27
Schutz	5,33	32	6	14,9	42,5	2	53 - E	24
McCarron	5,46	42	7,6	17,4	32,8	1,9	58 - E	27
Gervais	6,32	34	5,3	14,6	86,2	1,5	56 - E	27
Turtle	8	24	3	7,3	165,1	2,4	51 - E	33
Owasso	14,29	56	2,8	12,2	155,4	2,2	58 - E	27
Centerville	14,59	40	3,7	5,8	187,8	1,2	62 - E	28
Colby	80	170	2,13	3,4	27,1	0,5	N/A - H	25
Loring	102	153	1,5	4,9	3,1	0,9	77 - H	22
Cedar	126,43	301	2,1	4,6	303,1	1,4	84 - H	20
Como	133,78	266	2,25	4,9	28,3	1,3	85 - H	23

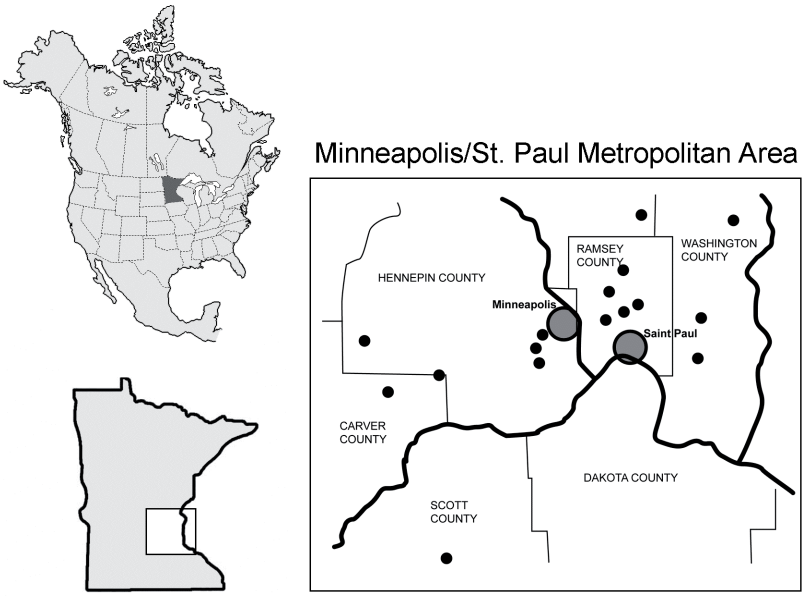

Fig. 1. Study sites marked with black dots in the Minneapolis/St. Paul Metropolitan Area.

RESULTS

Over the course of the study 14,148 SFPE were collected with a mean of 875 exuviae per lake. The exuviae represented 51 total genera, with the range per lake from 20 to 35 genera. Ten genera (20%) were common to all 16 lakes. The chironomid community consisted of 9 Tanypodinae genera, 10 Orthocladiinae genera and 33 Chironominae genera. Within Chironominae, there were 8 Tanytarsini genera, 1 Pseudochironomini genus and 24 Chironomini genera.

For one sample date, maximum detection efficiency ranged from 59% to 82% (Table 2). Two samples increased maximum detection efficiency to 79% - 100%; three samples per season had a maximum detection efficiency of 86% - 100%, and four samples per season ranged from 91% - 100% (Fig. 2). Six lakes (38%) had 100% detection efficiency with four samples and an additional six lakes (38%) were only missing one taxon with four sample dates. The four remaining lakes were missing two taxa with four sample dates, yet two of these lakes had the highest generic richness and the other two yielded less specimens over the sample period than the mean exuviae collected per lake.

The most genus-rich month per lake ranged from May to August. Eleven lakes (69%) had the highest richness in May or June, with the most lakes having the highest richness in June (Table 2).

Generic richness decreased with increasing ratio of mean epilimnetic phosphorus/ mean lake depth, R^2=0.56 (Fig. 3). Turtle lake (#10) had low total phosphorus (24mg/l),

but also a shallow mean depth (3m) which resulted in a phosphorus to mean depth ratio of 8mg/L/mld (Table 1). Turtle lake was also the second highest in generic richness (Table 1). When this lake was moved to fifth in the order on Fig. 3 instead of tenth, the variance explained increased, R^2=0.71.

TABLE 2. Proportion of total generic richness collected each month for each lake. The most genus-rich month is bolded; lakes are sorted by mean P/mean depth.

	April	May	June	July	Aug.	Sept.	Oct.
Elmo	0,15	**0,59**	**0,59**	0,38	0,56	0,47	0,21
Christmas	0,39	0,52	**0,61**	0,26	0,55	0,45	0,16
Square	0,16	0,28	**0,81**	0,75	0,56	0,38	0
Little Long	0,23	**0,62**	0,19	**0,62**	0,42	0,42	0
Calhoun	0,35	0,45	0,48	0,58	**0,71**	0,48	0
Harriet	0,26	0,52	**0,74**	0,44	0,59	0,59	0,22
Schutz	0,21	0,46	0,63	0,58	**0,71**	0,5	0,04
McCarron	0,11	0,39	0,57	**0,64**	0,32	0,43	0,11
Gervais	0,3	0,3	0,63	0,52	**0,7**	0,26	0
Turtle	0,09	0,61	**0,67**	0,64	0,45	0,45	0,06
Owasso	0,44	0,52	0,63	0,74	**0,81**	0,74	0
Centerville	0,5	0,57	0,64	**0,82**	0,25	0,29	0,07
Colby	0,25	0,67	**0,75**	0,5	0,71	0,21	0
Loring	0,09	**0,74**	0,17	0,43	0,52	0,39	0,13
Cedar	0,43	**0,67**	0,48	0,62	0,33	0,52	0
Como	0,48	**0,65**	0,35	0,48	0,57	0,22	0

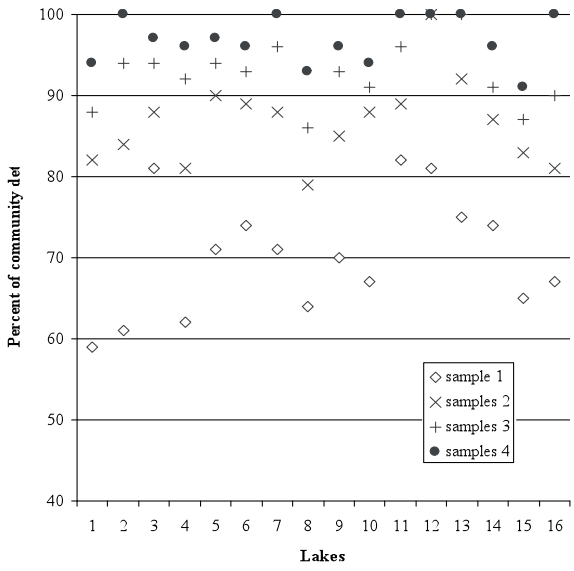

Fig. 2. Percent of the chironomid community detected with 1-4 sample dates during the ice-free season of 2005 (April – October).

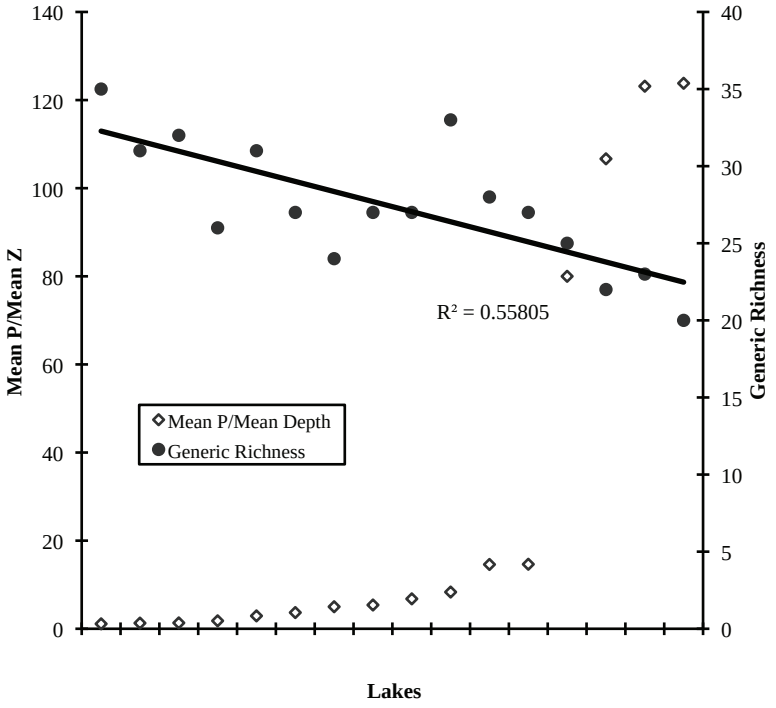

Fig. 3. Generic richness compared to mean P/mean lake depth (μm/L/m).

DISCUSSION

We believe we found a relatively simple way for lake managers to determine the abundant taxa of the chironomid community present in urban lakes of contrasting trophic states. Collecting SFPE only takes 10 minutes effort per sample day per lake (FERRINGTON *et al.* 1991), and we found that four samples per lake per season are sufficient to characterize the abundant taxa of the chironomid community for the purpose of creating a model to determine trophic state.

Four sample dates per season detected most of the abundant taxa in TCMA lakes (91%-100%). These urban lakes ranged from hypereutrophic (phosporus/mld 133 mg/l/m) to mesotrophic (phosporus/mld 1.1 mg/l/m). In all lakes, the April samples contained different taxa than May through August samples; therefore, we recommend sampling four times a season, with one sample in April and three samples between May and September. If one only has the resources to sample three times a season, a majority of taxa will still be recovered (86%-100%). For a three month sample schedule, we recommend sampling April, June and July. For a two month sample schedule, we recommend sampling April and once between June and July. For just one sample a season, we recommend sampling in June.

As we expected, the generic richness was correlated with the phosphorus to mean lake depth ratio. Lakes with less phosphorus (mesotrophic and oligotrophic) are able to support a more heterogeneous chironomid community with a wider range of tolerances to organic enrichment. In lakes with more phosphorus (eutrophic and hypereutrophic), the intolerant taxa cannot be sustained and a more homogeneous, less diverse community is present.

The aim of this study was to help lake managers and chironomidologists determine how many sample dates are necessary to categorize abundant taxa of the community using SFPE. Since a higher generic richness is predicted for oligotrophic lakes, one may need more seasonal samples to detect a similar percentage of the total community.

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