SAMPLING EFFICIENCY OF CHIRONOMIDAE (DIPTERA) ACROSS DISTURBANCE GRADIENTS

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With 1 figure and 3 tables

ABSTRACT: We compared detection efficiency and number of exclusively collected genera for surface-floating pupal exuviae and dipnet methods across two disturbance gradients. The most efficient method was collecting exuviae monthly. When compared for June only, the dipnet method was most effective across all sites, but at disturbed sites there were no statistically significant differences between methods. The exuviae method exclusively collected twice as many genera as the dipnet method.

RESUMO: Comparamos a eficiência de detecção com o número de géneros exclusivamente recolhidos para exuviae de superfície - pupas flutuantes e métodos de rede de mão, entre dois gradientes de perturbação. O método mais eficiente foi a colheita exuviae, realizada mensalmente. Efectuando a comparação exclusivamente com o mês de Junho, o método tipo rede de mão foi o mais eficiente em todos os locais de amostragem, mas em locais com perturbação não se verificou significância estatística entre os dois métodos. O método de exuviae exclusivamente, coleccionou duas vezes mais géneros, tal como o método tipo rede de mão.

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INTRODUCTION

Members of the Chironomidae are usually the most abundant insects in lotic and lentic habitats (COFFMAN, 1973; PINDER, 1986). Given their prominence in aquatic ecosystems, sampling methods must efficiently detect the extant chironomid community. Chironomid sampling methods are usually larval or pupal exuviae based, depending upon the life stage that is targeted. The dipnet method is used to collect larvae whilst various pan and sieve methods capture the surface-floating pupal exuviae (SFPE) left behind after eclosion of the adult.

Only a handful of studies have combined larval and SFPE methods in a single study. Examples include CHUTTER (1984), RUSE & WILSON (1984), FERRINGTON *et al*. (1991), BARTON *et al*. (1995), and RUSE (1995a,b) in lotic habitats, and KETELAARS *et al*. (1992) and KUIJPERS *et al*. (1992) in lentic habitats. Although BARTON *et al*. (1995) used both larval and SFPE methods, only FERRINGTON *et al*. (1991) examined the efficacy of the methods used concurrently in lotic systems although some studies qualitatively compare the collection of efficiencies of both methods (e.g. KUIJPERS *et al*., 1992; BARTON *et al*., 1995; RUSE, 1995b).

A comparison of method efficacy has important implications for biological monitoring experimental design. This paper aims to compare the collection efficiencies of SFPE versus dipnet methods across two disturbance gradients consisting of (1) all sites and (2) a subset of the four most disturbed sites in a ditched stream. Genera collected exclusively by each method are also evaluated.

MATERIALS AND METHODS

The eight sample sites were located in Hardwood Creek (71km^2 catchment), situated in a rapidly urbanizing watershed 34 kilometres northeast of Minneapolis and St. Paul, Minnesota, USA. Hardwood Creek flows from Rice Lake into Peltier Lake (Fig. 1), part of the Rice Creek watershed. The four upstream sites (1.5U, 1.5D, 1.4 and 1.3) were most disturbed due to dredging. Sites 1.5U and 1.4 were dredged in winter of 2004, while 1.5D and 1.3 were last dredged in the 1970's. The four downstream sites (1, 1.1, 1.2 and 2) were less disturbed by dredging. Sites 1 and 1.1 were dredged in the 1950's and 1960's, while there is no record of ditching at 1.2 and 2. Disturbed upstream site substrate largely consisted of peat while that of the downstream sites was primarily sand. Riparian vegetation at the upstream sites comprised mainly tall grasses while riparian zones of downstream sites contained deciduous trees.

In June 2004, benthic samples were taken using a d-framed dipnet (500 µm mesh). Bank, bottom, wood, and riffle habitats were sampled independently, when present (Table 1). Three consecutive samples per habitat were taken except at sites 1, 2, and 1.2 where bottom, bank, and bottom habitats were sampled five, two, and four times respectively. These habitats were sampled by one to three jabs and/or a half-meter sweep, whereas riffles were sampled by five boot kicks upstream of the net. SFPE were sampled approximately monthly from April through November 2004 following the protocol of FERRINGTON *et al*. (1991).

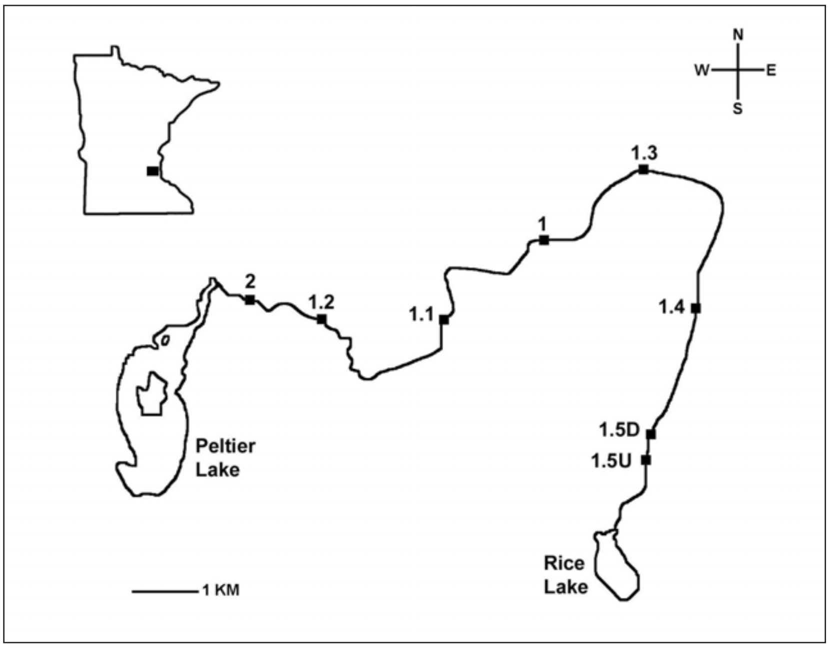

Fig. 1. Sample site locations on Hardwood Creek in Minnesota, USA.

TABLE 1. Conditions at sample sites. "YES" = habitat present and sampled with dipnet in June 2004. "NO" = habitat was not present.

Sample Site	History of Ditching	Habitats Present: Bank	Bottom	Wood	Riffle
1.5 U	Winter 2004	YES	YES	NO	NO
1.5 D	1970's	YES	YES	YES	NO
1.4	Winter 2004	YES	YES	NO	NO
1.3	1970's	YES	YES	YES	NO
1	1950/1960's	YES	YES	YES	NO
1.1	1950/1960's	YES	YES	YES	NO
1.2	Never	YES	YES	YES	YES
2	Never	YES	YES	YES	NO

Dipnet samples larger than approximately 90% of a 500 ml sample bottle were subsampled (half of the sample was randomly selected, picked, and preserved). Chironomidae larvae were prepared, mounted in Euparal® under a dissecting microscope and identified under a compound microscope. SFPE samples were not subsampled. Exuviae were identified to lowest practical level with a dissecting microscope.

Eight paired t-tests were performed using JMP IN 5.1.2 software (SAS Institute) to compare collection efficiencies of both methods. Percent of the chironomid community and number of chironomid genera were used as metrics for each site to evaluate collection efficiencies. Analyses were made (1) across all sites (2) the four most disturbed sites for larvae and exuviae collected in June (3) exuviae collected approximately monthly. Data analysis was carried out on data at genus level to provide consistency. Genera collected exclusively by the surface-floating pupal exuviae (ESFPE) and dipnet (EDN) methods were summed across all sites and collection dates.

RESULTS

Hypotheses one, three, five, and seven confirmed that when applied approximately monthly SFPE method was significantly more effective detecting genera, across both disturbance gradients (Table 2).

TABLE 2. Hypotheses (H), metrics tested, site comparisons, collection dates, means, and p-values used to evaluate eight hypotheses of SFPE and dipnet method detection efficiencies.

H	Metric Tested	Sites Included	SFPE Collections	DN Collections	SFPE Mean	DN Mean	P
1	Percent of Community	All	Aproximately Monthly	June	82.3	61.8	0.0125
2	Percent of Community	All	June	June	48.0	83.8	0.0060
3	Number of Genera	All	Approximately Monthly	June	30.9	23.9	0.0068
4	Number of Genera	All	June	June	12.8	23.9	0.0070
5	Percent of Community	Four Most Disturbed	Approximately Monthly	June	85.9	55.6	0.0376
6	Percent of Community	Four Most Disturbed	June	June	56.7	74.5	0.2658
7	Number of Genera	Four Most Disturbed	Approximately Monthly	June	26.5	17.3	0.0390
8	Number of Genera	Four Most Disturbed	June	June	12.5	17.3	0.2845

Seventy-one genera and 129 species were detected as pupal exuviae across all sample sites. Twenty genera were collected ESFPE (Table 3) of which *Eukiefferiella* sp. and *Orthocladius* sp. were collected in large numbers (545 and 171 specimens respectively). ESFPE genera exclusive to June were *Demeijeria* sp., *Gillotia/Parachironomus* sp., and *Guttipelopia* sp.

Hypotheses two and four confirmed the dipnet method was significantly more effective for detecting genera in June across all sites (Table 2). For hypotheses six and eight, there was no statistical difference between either method during June at the four most disturbed sites (Table 2). Fifty-one genera were detected as larvae across all sample sites. Ten genera were collected EDN (Table 3). Of these only *Paralauterborniella* sp. was collected in large numbers, with 39 specimens collected. There were no genera collected EDN in June.

TABLE 3**.** The number of specimens collected exclusively by the surface-floating pupal exuviae method (ESFPE) and the dipnet method (EDN). An asterisk (*) denotes taxa only collected in June.

Genera	ESFPE	EDN
Orthocladiinae		
Chaetocladius sp.	3	—
Diplocladius sp.	1	—
Eukiefferiella sp.	545	—
Hydrobaenus sp.	1	—
Limnophyes sp.	21	—
Orthocladius sp.	171	—
Paraphaenocladius sp.	6	—
Pseudosmittia sp.	8	—
Stilocladius sp.	—	1
Chironomini		
Demeijeria sp. *	1*	—
Einfeldia sp.	—	2
Endotribelos sp.	—	2
Harnischia sp.	13	—
Microchironomus sp.	—	18
Microtendipes sp.	3	—
Paralauterborniella sp.	—	39
Stictochironomus sp.	2	—
Gillotia/Parachironomus sp. *	6*	—
Tanypodinae		
Clinotanypus sp.	—	1

TABLE 3. (Cont.)

Genera	ESFPE	EDN
Conchapelopia sp.	28	—
Guttipelopia sp. *	2*	—
Labrundinia sp.	25	—
Larsia sp.	13	—
Monopelopia sp.	—	1
Natarsia sp.	3	—
Paramerina sp.	7	—
Pentaneura sp.	—	3
Thienemannimyia gr.	—	13
Zavrelimyia sp.	3	—
Prodiamesinae		
Odontomesa sp.	—	2
Total by Collection Method	20	10

DISCUSSION

This study compared the detection efficiencies of the SFPE and dipnet methods across two disturbance gradients and determined genera collected ESFPE and EDN. When applied approximately monthly across both disturbance gradients, the SFPE method,was significantly more efficient in detecting genera than the dipnet method applied only in June (Table 2). We would expect samples taken across a greater temporal scale would be more efficient at detecting different chironomid species, given their diverse phenologies. Conversely, the dipnet method was significantly more efficient, for both metrics at all sites (Table 2), when only June samples of SFPE were compared. Although SFPE detected 71 genera, the mean number of genera detected per sample date ranged from 12.5 to 30.9, clearly demonstrating that not every genus emerged concurrently. As a result, dipnet samples for developing larvae could be expected to yield more chironomid genera than would be detected on a single collection date for SFPE.

At the four most disturbed sites in June there was no significant difference between methods (Table 2), likely due to low power of the test, related to only three degrees of freedom in the statistical analysis. This explanation was supported by the June comparisons across all sites, which had 7 degrees of freedom and confirmed statistically significant differences.

The SFPE method collected twenty genera exclusively, whereas the dipnet methods collected ten general exclusively (Table 3) when summed for all sites and sample dates. BARTON *et al*. (1995) also found that approximately twice as many taxa were exclusively collected by their exuvial method compared to the dipnet method, since exuvial material allows species level identifications. However, BARTON *et al*. (1995)

found exuviae at only 35% of their sites, so the number of genera found as exuviae would be expected to increase with sampling effort. The number of exclusively collected taxa were calculated from RUSE (1995b), where it appears that approximately four times as many unique taxa were collected by the exuviae method. However, RUSE (1995b) also noted that many larvae could not be identified to species.

Only *Limnophyes* sp. was exclusive to exuvial collections in this study and RUSE (1995b), (Table 3). *Chaetocladius* sp., *Larsia* sp., and *Zavrelimyia* sp. were exclusive to larval collections by RUSE (1995b), but we collected them ESFPE (Table 3). Exclusively occurring genera likely reflect similarities and differences of sampling methods and/or species phenologies within the genera collected. No other combined larval and exuviae studies list exclusively collected taxa, so further comparisons cannot be made.

This study supports the conclusion of KUIJPERS *et al*. (1992), that exuviae and benthic methods supplement each other and are particularly important if a comprehensive assessment of chironomid fauna biodiversity is an objective of the research.

In conclusion, the best single strategy for detecting chironomid species was collecting SFPE approximately monthly, compared to June dipnet samples (a common procedure in monitoring programmes), applicable across non-ditched to recently-ditched sites, and a disturbance gradient containing recently and less-recently ditched sites in Hardwood Creek. However, if June is the only month when sampling can occur, the dipnet method is more efficient in Hardwood Creek. There was no significant difference between methods across highly disturbed sites in June, so either method would be appropriate. Monthly SFPE collections in Hardwood Creek will collect twice as many exclusive genera as June dipnet samples. Consequently, both SFPE and dipnet methods should be used if a comprehensive assessment of the biodiversity of the chironomid fauna is needed.

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