

## NUMERICAL ABUNDANCE VALUES OF MAYFLY NYMPHS FROM THE HOLARCTIC REGION

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### ABSTRACT

Members of seven Holarctic families, Heptageniidae, Baetidae, Ephemerellidae, Leptophlebiidae, Ephemeridae, Caenidae, and Siphonuridae, accounted for 96% of the reported abundance values. *Baetis* and *Ephemerella* were the most reported taxa for the entire Holarctic region. In North America, the order was *Ephemerella*, *Baetis*, and *Hexagenia*. *Baetis rhodani*, a Palaearctic species, was the most reported species. For the total mayfly fauna, the mean of all average yearly abundance values was 375/m<sup>2</sup>. Of these average yearly abundance values, 21% of the values were less than 100/m<sup>2</sup> and 93% were less than 700/m<sup>2</sup>.

### INTRODUCTION

Since 1966 I have been studying limnological features of a brown-water stream in west-central Alberta, Canada. Numerical estimates of abundance, especially for immature mayflies, have been an integral part of certain studies of this brown-water stream. The absolute values have been important and valid facets of temporal and spatial distribution studies for a single area within this stream. But what is the importance of abundance estimates when culled from the literature for comparative purposes? There now exists a voluminous literature dealing in part with the abundance of aquatic invertebrates per unit of substrate area. Indeed, estimating number of invertebrates per unit area seems to be a routine procedure in stream work. However, numerous confounding factors would seem to make these estimates almost impossible to evaluate when used for comparative purposes.

Chief among these are the large variability in numbers per unit area over short stretches of the substrate and the very large seasonal changes in numbers for certain taxa. Hynes (1970) and Pennak (1977) discuss many of the factors affecting the validity of quantitative sampling of stream benthos. Both agree that some measure of abundance is essential for understanding the biology of stream organisms. The prodigious number of reported density values for certain taxa, in itself, commands respect; and it would be instructive to attempt some sort of comparative analysis of these reported abundance values.

## METHODS

I surveyed 152 articles that reported abundance values of mayfly nymphs from the Holarctic region. The factors that make these estimates difficult to evaluate when used for comparative purposes were disregarded. The values were separated into two groups: (1) number per unit area at any one time, and (2) where samples were taken throughout the year, average yearly abundance values. The values at "any one time" were either from a single unit area sample (e.g. 0.09 m<sup>2</sup>) or from the average of several samples from the same site. Occasionally, the values of each of several unit area samples for a single site would be reported; in these cases, I simply took the maximum value, on the premise that abundance estimates generally tend to be conservative. The data were treated mainly in a relative sense, with as much emphasis on the frequency that a taxon was reported as on the absolute abundance value. For some of the relative compilations, the Nearctic (i.e. U.S.A. and Canada, there being no reports from Mexico) reports were treated separately. Most of the Palaearctic reports came from Poland (26%), Great Britain (24%), Czechoslovakia (17%), Japan (12%), and Sweden (11%).

A similar analysis was also attempted for biomass (standing crop), but there were not enough values derived by the same weighing procedure to make comparisons meaningful. For nymphal wet weights of individual taxa per unit area, there were too many weighing procedures (resulting in very wet weight to almost dry weight). And of the few dry weight values derived by comparable procedures, about 75% dealt with a single taxon, *Hexagenia*. Hence, the ensuing analysis is restricted to numerical abundance, i.e. numbers per square meter.

## RESULTS

### *Taxa Frequency*

*Taxa within each family.* Abundance values were available for 15 of the 18 Holarctic families. For the entire Holarctic region, taxa within two families, Heptageniidae and Baetidae, accounted for about half of the reported values; and taxa within only seven families

accounted for 96% of all reported abundance values (Table 1). In North America, taxa within Heptageniidae and Ephemerellidae were most important, and taxa of only 5 of the 16 Nearctic mayfly families accounted for 83% of the Nearctic values.

Table 1. Percent number of times that numerical abundance values were reported for taxa within each family.

| Holarctic         | %  | Nearctic only   | %  |
|-------------------|----|-----------------|----|
| Heptageniidae     | 25 | Heptageniidae   | 25 |
| Baetidae          | 23 | Ephemerellidae  | 21 |
| Ephemerellidae    | 18 | Baetidae        | 15 |
| Leptophlebiidae   | 11 | Ephemeridae     | 12 |
| Ephemeridae       | 8  | Leptophlebiidae | 10 |
| Caenidae          | 6  | Siphonuridae    | 6  |
| Siphonuridae      | 5  | Caenidae        | 5  |
| Tricorythidae     | 2  | Tricorythidae   | 2  |
| Polymitarcyidae   | <1 | Polymitarcyidae | <1 |
| Potamanthidae     | <1 | Potamanthidae   | <1 |
| Oligoneuriidae    | <1 | Oligoneuriidae  | <1 |
| Baetiscidae       | <1 | Baetiscidae     | <1 |
| Metretopodidae    | <1 | Metretopodidae  | <1 |
| Ametropodidae     | <1 | Ametropodidae   | <1 |
| Prosopistomatidae | <1 |                 |    |

*Genera and species.* *Baetis* and *Ephemerella* were, by a considerable margin, the most reported genera for the entire Holarctic region (Table 2). In the Nearctic region, *Ephemerella* accounted for twice as many of the reported values than did any other mayfly genus. *Baetis rhodani* Pictet, a Palaearctic species, was the most reported species. Although the North American fauna was not dominated by any one species, there were slightly more abundance values for *Hexagenia limbata* (Serville), *Ephemerella doddsi* Needham and *Baetis vagans* McDunnough than for other Nearctic species.

In North America, Ephemerellidae (single genus *Ephemerella*) was the only major family exhibiting a large percentage of abundance values at the species level (Table 3). In contrast, for the Palaearctic fauna, abundance values of all families except Caenidae and Siphonuridae were reported at the species level at least 80% of the time. Most of the Palaearctic values pertained to mayflies of Europe, where in many areas mature nymphs can be identified to species for almost all families. In North America, the only inclusive nymphal keys to the species level for a major taxon are those for *Ephemerella*

by R.K. Allen and G.F. Edmunds, Jr. This would seem to be mainly responsible for the relatively high percentage of ephemereleid abundance values at the species level and certainly appears to be good ecological evidence for the usefulness of such keys.

Table 2. Number of times numerical abundance values were reported for the 10 most reported genera.

| Holarctic                  | No. | Nearctic only              | No. |
|----------------------------|-----|----------------------------|-----|
| <i>Baetis</i>              | 64  | <i>Ephemerella</i>         | 39  |
| <i>Ephemerella</i>         | 63  | <i>Baetis</i>              | 16  |
| <i>Rhithrogena</i>         | 24  | <i>Hexagenia</i>           | 16  |
| <i>Hexagenia</i>           | 16  | <i>Stenonema-Stenacron</i> | 14  |
| <i>Stenonema-Stenacron</i> | 14  | <i>Paraleptophlebia</i>    | 10  |
| <i>Caenis</i>              | 13  | <i>Rhithrogena</i>         | 8   |
| <i>Paraleptophlebia</i>    | 13  | <i>Caenis</i>              | 7   |
| <i>Ecdyonurus</i>          | 12  | <i>Tricorythodes</i>       | 5   |
| <i>Epeorus</i>             | 10  | <i>Isonychia</i>           | 5   |
| <i>Isonychia</i>           | 8   | <i>Cinygmula</i>           | 5   |

Table 3. Percent number of abundance values within each of the major families reported at the species level.

|                 | Holarctic<br>% | Palearctic<br>% | Nearctic<br>% |
|-----------------|----------------|-----------------|---------------|
| Ephemerellidae  | 85             | 95              | 80            |
| Baetidae        | 69             | 94              | 29            |
| Heptageniidae   | 58             | 81              | 37            |
| Leptophlebiidae | 47             | 92              | 16            |
| Siphonuridae    | 41             | 57              | 30            |
| Ephemeridae     | 28             | 100             | 18            |
| Caenidae        | 26             | 36              | 11            |

*Lentic habitats.* Only 5% of all values pertained to mayflies from lentic habitats. Taxa of Ephemeridae, mainly *Hexagenia*, accounted for 65% of these abundance values, followed by taxa of Caenidae (12%), Leptophlebiidae (12%), and other families (11%).

*Absolute Values*

*Taxa exhibiting large densities.* Of all abundance values reported as  $> 1000/m^2$  at one sampling time, three genera, *Baetis* (41%), *Ephemerella* (19%), and *Caenis* (16%), accounted for 76% of the values for the entire Holarctic region. In North America, *Baetis* (25%), *Ephemerella* (20%), *Hexagenia* (20%), and *Caenis* (15%) accounted for 80% of the values. Rarely, mayfly nymphs, usually the total mayfly fauna, but sometimes a single taxon, were reported as occurring in very large numbers, over  $10,000/m^2$ . The mayflies of most of these reports were either associated with aquatic macrophytes or the collecting equipment sampled deep into fairly loose substrates. Hence, numbers per unit area would probably not be an accurate expression of abundance in these cases. Numbers per unit volume of substrate would seem more appropriate.

*Average yearly abundance values.* These are values derived mainly from semimonthly, monthly, or bimonthly samples throughout the year and then averaged. For the total mayfly fauna, 21% of the average yearly values were  $< 100/m^2$  and 93% were less than  $700/m^2$  (Table 4). The mean was  $375/m^2$  and the median was  $320/m^2$ . The largest average yearly abundance value for the total mayfly fauna was  $1448/m^2$ , but there were indications from some of the non-yearly reports that had samples been taken throughout the year the maximum average yearly value would have been considerably higher than  $1448/m^2$ .

Table 4. Percentage numbers and cumulative percentages of all average yearly abundance values (entire Holarctic region) for each of eight categories. Values represent the total mayfly fauna.

| Numbers/ $m^2$ | %  | Cumulative % |
|----------------|----|--------------|
| < 100          | 21 | 21           |
| 100-199        | 16 | 37           |
| 200-299        | 9  | 46           |
| 300-399        | 14 | 60           |
| 400-499        | 7  | 67           |
| 500-599        | 12 | 79           |
| 600-699        | 14 | 93           |
| > 700          | 7  | 100          |

Means of average yearly abundance values for genera having mean values  $> 10/m^2$  were: *Baetis* ( $325/m^2$ ), *Ephemerella* ( $130/m^2$ ), *Hexagenia* ( $83/m^2$ ), *Caenis* ( $32/m^2$ ), and *Stenonema-Stenacron* ( $14/m^2$ ). Although one must treat these absolute values cautiously, they do indicate the relatively great abundance of *Baetis* and, to a lesser extent, *Ephemerella* nymphs in Holarctic regions.

## DISCUSSION

Although there are 18 families of known Holarctic mayflies, only a small number of genera within a few families contribute much to the reported numerical abundance values. In many aquatic systems there are only a few relatively abundant mayfly species when abundance is considered in terms of the entire year. This seems especially true in northern waters. Ulfstrand (1975) studied the mayfly fauna of several streams in Swedish Lapland and found that one species, *Baetis rhodani*, accounted for over 50% of all the mayfly nymphs collected. In a brown-water stream of Alberta, Canada, which I have been studying since 1966, there are 18 mayfly species; but two species, *Leptophlebia cupida* (Say) and *Baetis tricaudatus* Dodds, account for 80% of the nymphs, and this is when averaged over several years (Clifford 1978). Perhaps, in a sense, this is fortunate for ecologists studying stream communities, since we can put our efforts into studying the few abundant mayfly species and be quite certain we are obtaining data on the important mayfly contributors to community structure.

Why are nymphs of the genus *Baetis* relatively so abundant? In respect to my survey, *Baetis* leads all taxa in number of reported values, number of values  $> 100/m^2$ , and average yearly abundance values. Perhaps species richness within the genus is important. Also, Macan (1958) suggests that catchability might have something to do with the large numbers of *Baetis* nymphs that are often reported in abundance studies. Certainly it is well-documented that *Baetis* nymphs exhibit a great propensity to drift, at least in temperate regions. The *Baetis* phenomenon does pose interesting ecological problems and suggests, especially in North America, important lines of taxonomic research. For a mayfly ecologist in North America, a species key to *Baetis* nymphs would be a most valuable tool.

## RESUME

Les insectes appartenant à sept familles holarctiques, les heptagénéiidés, les baetidés, les leptophlébiidés, les éphéméridés, les caenidés et les siphonuridés comptent pour 96% des quantités d'insectes signalés. Les *Baetis* et les *Ephemerella* sont les taxons le plus souvent relevés dans la région holarctique tour entière. En Amérique du nord, l'*Ephémérella* vient en premier lieu, suivi de

la *Baetis* puis de l'*Hexagénie*. La *Baetis rhodani*, espèce paléarctique, est l'espèce la plus souvent signalée. La moyenne proportionnelle de l'agrégat des quantités annuelles moyennes de toute la faune d'éphéméroptères s'établit à 375/m<sup>2</sup>. De ces quantités annuelles moyennes, 21% étaient inférieures à 100/m<sup>2</sup> et 93%, à 700/m<sup>2</sup>.

#### ZUSSAMENFASSUNG

Mitglieder von sieben holarktischen Familien: *Heptageniiden*, *Baetiden*, *Ephemerelliden*, *Leptophlebiiden*, *Ephemeriden*, *Caeniden* und *Siphonuriden* lieferten 96% der aufgeführten Abundanzwerte. *Baetis* und *Ephemerella* waren die häufigst gemeldeten Taxa für die gesamte holarktische Region. In Nordamerika lautete die Reihenfolge dagegen: *Ephemerella*, *Baetis* und *Hexagenia*. *Baetis rhodani*, eine palaearktische Art, wurde am meisten genannt. Für die gesamte Eintagsfliegen Fauna war das Medium aller durchschnittlichen, jährlichen Abundanzwerte 375/m<sup>2</sup>. Davon beliefen sich 21% auf weniger als 100/m<sup>2</sup> und 93% auf weniger als 700/m<sup>2</sup>.

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