

# ABUNDANCE AND ALTITUDINAL DISTRIBUTION OF EPHEMEROPTERA IN A ROCKY MOUNTAIN STREAM

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## ABSTRACT

The nymphs of 29 species of Ephemeroptera representing six families were collected from rubble riffles in a Colorado stream system, from alpine tundra to the plains. Density ranged from 44 nymphs/m<sup>2</sup> at the headwater site to 2,031 nymphs/m<sup>2</sup> in the Foothills Limnological Zone. Heptageniidae comprised the majority of the mayflies at upstream sites and were numerically important at all but the plains location. Baetidae attained maximum diversity and relative abundance (62% of total mayflies) in the plains stream. Seven species of *Ephemere*llla exhibited overlapping distribution patterns from 3109 m a.s.l. to the plains.

## INTRODUCTION

The Colorado portion of the Cordilleran chain contains numerous peaks rising over 4,000 m above sea level (a.s.l.). The altitudinal gradient offers excellent opportunities to investigate factors which control the diversity, composition, and abundance of stream organisms. Illies and Botosaneanu (1963), and more recently Hynes (1970) and Hawkes (1975), have reviewed results of studies of longitudinal faunal changes in stream systems.

Remarkably little previous work on stream zonation has been conducted in Colorado. Dodds and Hisaw's (1925) pioneering study of South Boulder Creek employed only qualitative sampling techniques, was limited to the late June to early September period, and did not

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include physico-chemical data. Other studies have been limited in sampling period, altitudinal gradient, or taxonomic scope (Knight and Gaufin 1966, Elgmork and Saether 1970, Mecom 1972, Allan 1975).

St. Vrain Creek in the Front Range of Colorado flows freely from a glacier-fed source to the plains over an altitudinal gradient of nearly 1900 m. The ensuing data on the abundance and distribution of lotic Ephemeroptera as a function of altitude were collected during a comprehensive study of stream zonation which will be reported elsewhere.

## STUDY AREA AND METHODS

Middle St. Vrain Creek begins near the St. Vrain Glaciers, which occupy cirques on the east side of the Continental Divide in northern Colorado. The stream originates in alpine tundra (3414 m a.s.l.) and drops 1870 m to the plains over a distance of 54 km. The lakes and terrestrial vegetation of the region have been described in detail (Pennak 1958, Marr 1967). Bottom fauna-substrate relationships were examined at a single location on North St. Vrain Creek, a major tributary of the study stream (Ward 1975).

Benthic samples were collected from rubble riffles at eleven sites (Fig. 1). Six Surber samples (929 cm<sup>2</sup>) were taken from rubble riffles at each site, three with a regular mesh net (720  $\mu$ m) and three with fine mesh (240  $\mu$ m). Only the results of the regular mesh samples are reported herein.

From the Montane Limnological Zone (2633 m) to the plains, sampling was conducted monthly from June 1975-May 1976. Upper sites, which were reached by foot trail, were only accessible during summer due to the deep snowpack. Sites 4 and 5 were accessible by June, Sites 2 and 3 by July, but sampling at Site 1 was not possible until August due to an especially heavy snowpack the preceding winter. Because the open season is so short at higher elevations, it is unlikely that any common species were missed despite the restricted sampling period at upper sites.

Because of the difficulty of assigning species names to mayfly nymphs without associated adults for confirmation, question marks are used liberally to indicate uncertainty. Some identifications are presumptive because of the proximity of St. Vrain Creek to South Boulder Creek, from which several species were described by Dodds (1923), and the great likelihood of the streams having similar faunas. Edmunds' (1952) keys (with emendation, G.F. Edmunds, Jr., personal communication) were used to distinguish *Baetis* nymphs, although the confused state of *Baetis* taxonomy in North America is fully recognized.

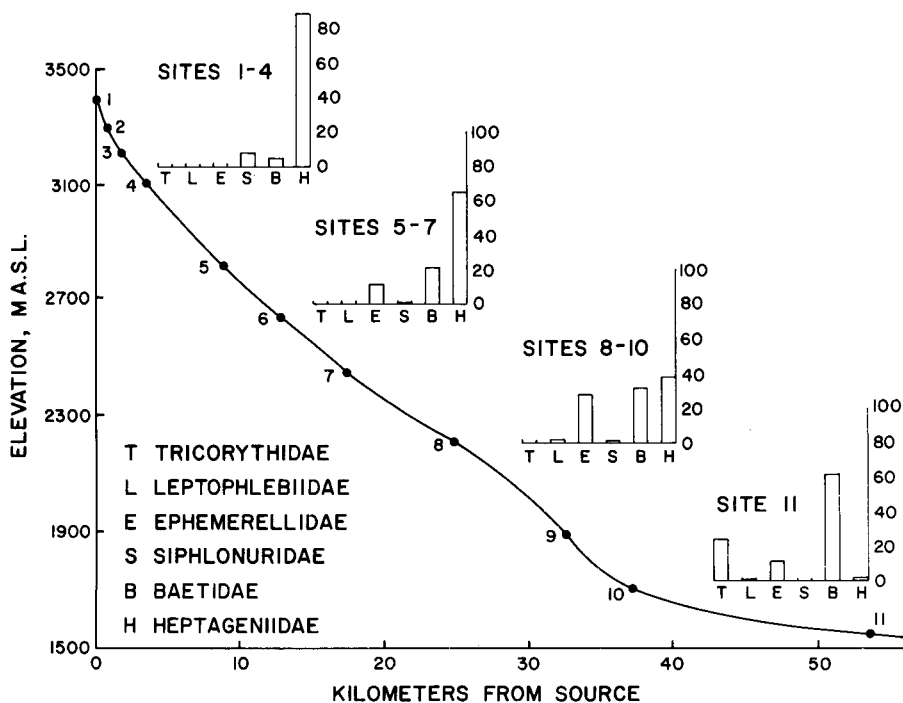


Figure 1. The relative contribution (mean % composition by density) of each family to total mayfly nymphs as a function of altitude in St. Vrain Creek, Colorado. Site locations are indicated by Arabic numerals on the longitudinal stream profile.

Detailed data on physico-chemical parameters, periphyton, and macrophytes were collected but will only be referred to briefly.

RESULTS AND DISCUSSION

The nymphs of 29 species of Ephemeroptera from six families were collected during the study. A few additional species not found as immatures in riffles (e.g., *Siphonurus occidentalis* Eaton) were collected in sweep nets. The number of species exhibited a general increase downstream. Only three species were found at Site 1 in the alpine tundra, whereas 18 species were collected at the plains location. The mean density ranged from 44 nymphs/m<sup>2</sup> at Site 1 to 2,031 nymphs/m<sup>2</sup> at Site 8 in the foothills. Density at the plains location (Site 11) averaged 1,060 nymphs/m<sup>2</sup>.

The extent to which various families contributed to the total mayfly fauna varied as a function of altitude (Fig. 1; the percentage representation by family is shown for sites at different elevations). Heptageniids exhibited a progressive decrease downstream and were the predominant mayflies at all but the plains location. Siphonurids were numerically important only at high elevations, whereas leptophlebiids (which were never abundant) were collected only at the lower sampling sites. The family Baetidae exhibited a progressive downstream increase in relative abundance, comprising 62% of total mayflies at Site 11. Ephemerellids reached a maximum relative abundance (28% of total mayflies) at Sites 8-10 in the foothills. The family Tricorythidae only occurred at the plains location where *Tricorythodes minutus* Traver comprised 24% of the mayfly fauna.

The nymphal species distributions observed during this study are presented in Figure 2. The altitudinal range appears greater in a few instances than shown for a given family in Figure 1 due to a small number of individuals which did not show up on the scale. A few species (e.g., *Baetis bicaudatus* Dodds) occurred over nearly

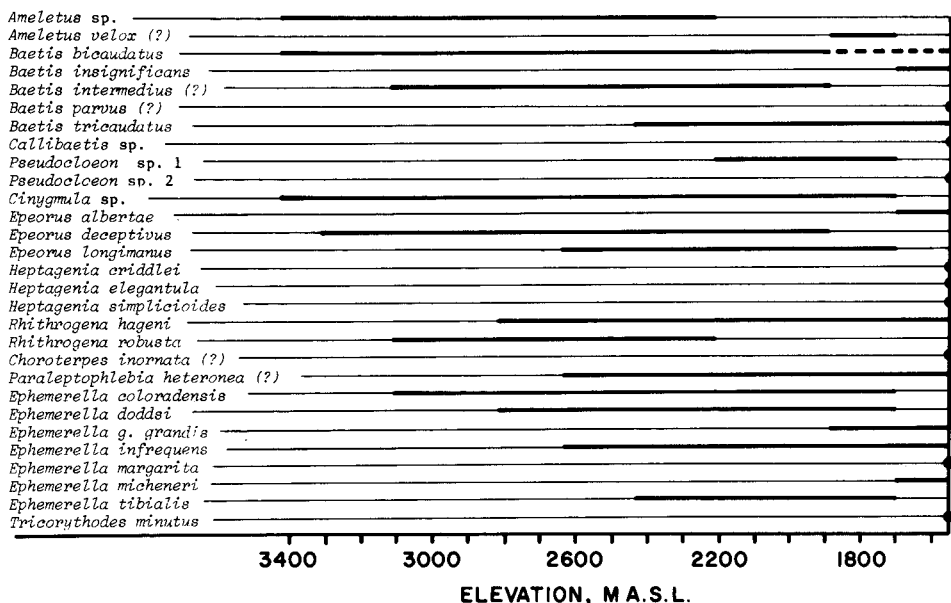


Figure 2. Altitudinal distribution (dark horizontal lines and solid circles) of Ephemeroptera nymphs in St. Vrain Creek, Colorado.

the entire altitudinal gradient. Nine species were found at only one location (solid circles on Figure 2); all of these were from Site 11 on the plains. Three additional species were collected only from the plains and the lowermost foothills site. No species was restricted to the headwaters. The three species occurring at Site 1 were all much more abundant at downstream locations and were found over all or nearly all of the altitudinal gradient. Although a few species were restricted to middle reaches, the general pattern appears to be a selective elimination of species toward higher elevations with only three species able to tolerate conditions in the alpine tundra stream.

Dodds (1923) collected mayflies over the same altitudinal range in a drainage system immediately to the south of St. Vrain Creek. Dodds listed 26 species of nymphs and adults, including specimens from lakes and ponds as well as from South Boulder Creek and its tributaries. Synonymies reduce that number to 24 species, only 13 of which were collected as nymphs from lotic waters, compared to 29 species of nymphs from St. Vrain Creek. The restricted sampling period (late June to early September) of the South Boulder study probably accounts for the smaller number of species, especially at lower elevations. Many of the species collected during the present study, but not reported by Dodds, were restricted to the plains site or to the plains and lowest foothills location (Fig. 2). Some of these species were represented by only a few individuals, whereas others (e.g., *Tricorythodes minutus*) were abundant, although restricted in distribution.

Elgmork and Saether (1970) conducted an intensive 4-day study in mid-July of the portion of North Boulder Creek above the tree line in which they reported that *Cinygmula mimus* (Eaton) occurred at higher elevations (3550 m) than any mayfly. *Baetis bicaudatus* Dodds and a few specimens of *Ephemerella coloradensis* Dodds were collected up to 3400 m. At Site 1 of the present study, three species of mayflies were collected, *Baetis bicaudatus*, *Ameletus* sp., and *Cinygmula* sp. *C. ramaleyi* "was the most abundant species in streams between 8,000 and 11,000 feet" in the South Boulder Creek Basin (Dodds 1923). Adult *Cinygmula par* (Eaton) were collected at Site 1 on St. Vrain Creek; the gills of the nymphs, however, contained a small fibrillar portion unlike *C. par*. Dodds reported *C. par* imagos at locations where *C. ramaleyi* nymphs were collected. In the present study, *Cinygmula* sp. nymphs were found at all except the plains locations with greatest density (958 individuals/m<sup>2</sup>) at Site 3.

The genus *Ephemerella* was represented by seven species. *E. coloradensis* occupied the widest range of altitude and extended the highest (Fig. 2), although not approaching the 3400 m upper limit reported by Elgmork and Saether (1970). *E. margarita* Needham was restricted to the plains.

Six species of *Ephemerella* occurred sympatrically at Site 10. *E. coloradensis* and *E. micheneri* Traver were represented by marginal populations of a few individuals at the lower and upper limits, respectively, of their altitudinal distribution. Three of the four remaining species, *E. g. grandis* Eaton, *E. infrequens* McD., and *E. doddsi* Needham, exhibited slow seasonal cycles (Hynes 1970). *E. tibialis* McD. showed a fast seasonal cycle. Analysis of production and life histories as a function of altitude will be presented in a later paper.

The distribution of stream organisms has been attributed to a variety of factors (Hynes 1970), many of which vary as a function of altitude and thus may be responsible, directly or indirectly, for the zonation pattern of Ephemeroptera. Although temperature and altitude determine oxygen solubility, it is unlikely that oxygen was limiting at any site since all values were near saturation. Variations in current and substrate were reduced by restricting sampling to rubble riffles.

Several physico-chemical parameters varied significantly with altitude. Stream size and associated changes in habitat diversity may be important since Site 1 is a first-order stream, whereas the plains stream is fifth-order. The pH increased from near neutrality in the headwaters to 8.1 in the plains stream. Total dissolved salts which averaged less than 10.0 mg/L at Site 1 increased to nearly 200 mg/L at Site 11. Suspended matter values and hardness also exhibited increases downstream. Many of these physico-chemical parameters varied only slightly between sampling sites in the mountains, but exhibited great increases from Site 10 to Site 11.

Mean summer temperatures increased from 2.3°C to 20.8°C over the altitudinal gradient. The importance of temperature in determining the distribution of stream fauna has been emphasized by several authors (e.g., Dodds and Hisaw 1925, Ide 1935, Kamler 1965, Hynes 1970), and most certainly plays a major role in determining the altitudinal ranges of species. The thermal pattern, as well as mean temperatures, must be considered (Lehmkuhl 1972, Ward and Stanford 1979).

Aquatic angiosperms were not encountered at mountain stream sites. The dense beds at the plains locations may provide microhabitats and current refugia not present at other sites.

Allochthonous inputs and *in situ* autochthonous production vary in quality and quantity over the gradient of altitude, thus providing a range of trophic conditions.

Other biotic factors, such as predation and competition, vary with altitude, although few studies have dealt with the influence of these phenomena in determining the distribution of Ephemeroptera

or other stream invertebrates. The presence of congeners may, for example, influence the niche breadth and therefore the altitudinal range of a species.

## CONCLUSIONS

Dodds and Hisaw concluded that "...there is one group of species confined to the high altitudes, another to low, and a third including those which have an extended range from low to high." In St. Vrain Creek, the general pattern appears to be the addition of species in the downstream direction without loss of those present at higher elevations (Fig. 2). However, a sharp faunal break occurs between Site 10 in the lower foothills and Site 11 on the plains coincident with the abrupt change in physico-chemical parameters. Seven species present at Site 10 were not collected at Site 11 during the year's study. In addition, nine species not found at mountain stream sites were collected at Site 11. Only three species were restricted to the middle range of elevation. In these cases, congeners occupy higher or lower elevations, or both.

The gradient of environmental conditions over short distances in the Front Range of the Colorado Rocky Mountains provides an ideal setting not only for investigating factors controlling distribution patterns and life cycle phenomena, but also for testing models of competitive interactions and segregation mechanisms.

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## RESUME

Les nymphes de 29 espèces d'éphéméroptères représentant familles furent recueillies dans des basses eaux rocailleuses du bassin d'un cours d'eau du Colorado s'étendant de la toundra alpine jusqu'aux plaines. La densité de population s'échelonnait de 44 nymphes/m<sup>2</sup> à l'origine à 2,031 nymphes/m<sup>2</sup> dans la zone limnologique des avant-monts. Vers l'amont, les heptagéniiidés formaient la majorité des éphéméroptères et elles étaient nombreuses à tous les endroits sauf dans la plaine. Dans le cours d'eau de la plaine c'étaient les bêtis qui étaient les plus variées et relativement les plus abondantes (62% du nombre total d'éphéméroptères). On a enfin découvert qu'il y avait chevauchement quant à la répartition de sept espèces d'*Ephemere* de 3109 mètresmer jusqu'aux plaines.

## ZUSSAMENFASSUNG

Nymphen von 29 Ephemeropterenarten aus sechs Familien wurden aus dem Geröll der Stromschnellen eines Flußnetzes in Colorado gesammelt, das sich von alpiner Tundra bis in die Ebene erstreckt. Die Densität schwankte zwischen 44 Nymphen/m<sup>2</sup> am Oberlauf und 2,031 Nymphen/m<sup>2</sup> in der limnologischen Zone des Vorgebirges. Heptageniiden stellten den Hauptanteil der Eintagsfliegen an stromaufwärts gelegenen Stellen dar und waren zahlenmäßig von Bedeutung an allen, außer den in der Ebene gelegenen Plätzen. Baetiden erreichten im Flußlauf der Ebene maximale Vielfalt und verhältnismaßig große Zahlen. (62% der gesamten Eintagsfliegen). Sieben Arten von *Ephemere*ll*a* wiesen sich überschneidende Verteilungspattern auf, bei Gebieten von 3,109 m ü. M. bis in die Ebene.

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