



Combined molecular and morphological phylogeny of Ephemerellinae (Ephemerellidae: Ephemeroptera), with remarks about classification

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Abstract

This study represents the first combined molecular and morphological analysis for the mayfly family Ephemerellidae (Ephemeroptera), with a focus on the relationships of genera and species groups of the subfamily Ephemerellinae. The phylogeny was constructed based on DNA sequence data from 3 nuclear (18S rDNA, 28S rDNA, histone H3) and 2 mitochondrial (12S rDNA, 16S rDNA) genes, and 23 morphological characters. Taxon sampling for Ephemerellidae included exemplars from all 25 extant genus groups and additional representatives from those genera with the highest diversity. Ephemerellidae appears to consist of three major clades. *Ephemerella*, the largest genus of Ephemerellidae, and *Serratella* were not supported as monophyletic, and each had representatives in two of the three major clades. However, the genera *Drunella* and *Cincticostella* were supported as monophyletic. Lineages strongly supported as monophyletic include a grouping of the Timpanoginae genera *Timpanoga*, *Dannella*, *Dentatella* and *Eurylophella*, and groupings of the Ephemerellinae genera *Torleya*, *Hyrtanella* and *Crinitella* and the genera *Kangella*, *Uracanthella* and *Teloganopsis*. The placement of the Timpanoginae genus *Attenella* fell within Ephemerellinae, based on molecular and combined data, but it grouped with other Timpanoginae based on morphological data alone. Further study and analysis of Ephemerellidae morphology is needed, and classification should be revised, if it is to reflect phylogenetic relationships.

Key words: Ephemeroptera; Mayflies; Molecular phylogeny; Pannota; Ephemerellidae

Introduction

The systematics of the mayfly family Ephemerellidae (Insecta: Ephemeroptera) has a long and complex history. Klapálek (1909) first recognized Ephemerellidae as a family group, but the concept dates back to Eaton's (Eaton, 1883–1888) section VI of *Ephemerella* Walsh. Allen (1965, 1980, 1984) and Edmunds et al. (1963) revised the composition of the family. During the last two decades, Ephemerellidae has been refined further as part of an effort to have taxonomic classifications that reflect phylogenetic hypotheses (McCafferty, 1991). The families Austremerellidae, Melanemerellidae, Philolimniidae, Teloganellidae, Teloganodidae and Vietnamellidae each contain genera that have been removed from Ephemerellidae as part of this effort (McCafferty & Wang, 1997; McCafferty & Wang, 2000; Jacobus & McCafferty, 2006).

Currently, the family Ephemerellidae is classified as part of the infraorder Pannota of the suborder Furcatergalia. Based on current classifications (Hong, 1979; McCafferty, 2000; McCafferty, Jacobus, & Wang, 2003; McCafferty & Wang, 2000; Sartori, 2004) the family Ephemerellidae includes the following genera: *Attenella* Edmunds, *Caudatella* Edmunds, *Caurinella* Allen, *Cincticostella* Allen, *Clephemera* Lin [fossil], *Crinitella* Allen and Edmunds, *Dannella* Edmunds, *Dentatella* Allen, *Drunella* Needham, *Ephacera* Paclt,