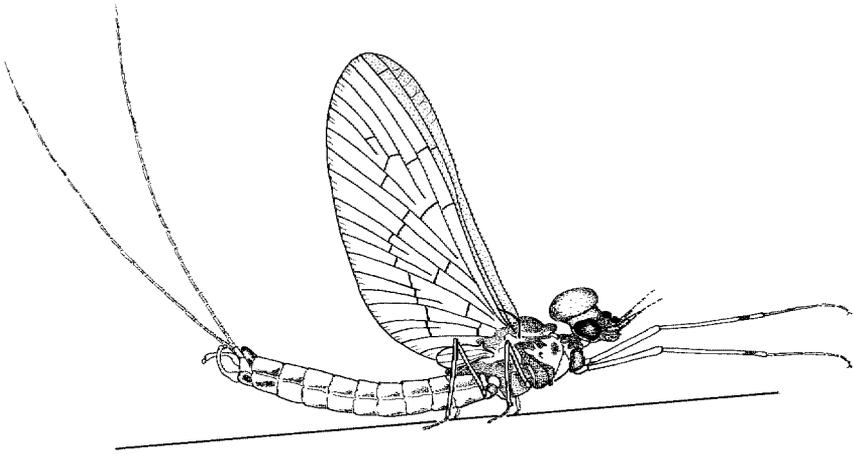


*Mayflies of the Yukon*



FRONTISPIECE. *Baetis bundyae* Lehmkuhl, adult male. This Holarctic mayfly occurs in the Yukon in arctic ponds south to about 60°N. Body length about 8 mm.

# Mayflies (Ephemeroptera) of the Yukon

P.P. HARPER and FRANÇOISE HARPER

Département de sciences biologiques  
Université de Montréal, C.P. 6128, succ. "Centre-ville"  
Montréal, Québec, Canada H3C 3J7

**Abstract.** Thirty taxa of mayflies are reported from the Yukon Territory. Four zoogeographical elements are recognized: 1) widespread Cordilleran and western coastal species, the largest group of species: *Acentrella insignificans*, *Caenis youngi*, *Callibaetis ferrugineus hageni*, *Cinygmula* spp., *Drunella* spp., *Epeorus longimanus*, *Rhiithrogena futilis*, *Siphonurus occidentalis*, and *S. phyllis*; 2) five Holarctic species: *Baetis bicaudatus*, *B. bundyae*, *Ephemerella mucronata*, *Metretopus borealis*, and *Siphonurus alternatus*; 3) four species of transcontinental distribution: *Baetis tricaudatus*, *Leptophlebia nebulosa*, *Paraleptophlebia debilis* and *Procloeon ingens*, and 4) the westernmost extension of the northeastern Nearctic fauna: *Heptagenia pulla* and *Siphloplecton prob. interlineatum*. There is no endemic element. This fauna is very similar in diversity and composition to that of Alaska, but much poorer than that of the adjacent Mackenzie Valley in the Northwest Territories. It appears to be composed largely of the hardiest species of the western boreal fauna, with some eastern elements, but with few truly arctic components. Such a depauperate fauna may be due to particularly harsh climatic and ecological conditions and/or zoogeographical barriers, but it is not possible at the present time to rule out insufficient collecting as an important factor.

**Résumé.** Les éphéméroptères (Ephemeroptera) du Yukon. Sur le territoire du Yukon, nous avons inventorié 30 taxons d'éphéméroptères, parmi lesquels nous reconnaissons quatre éléments zoogéographiques: 1) des espèces néarctiques occidentales à répartition géographique étendue qui forment le groupe principal d'espèces: *Acentrella insignificans*, *Caenis youngi*, *Callibaetis ferrugineus hageni*, *Cinygmula* spp., *Drunella* spp., *Epeorus longimanus*, *Rhiithrogena futilis*, *Siphonurus occidentalis* et *S. phyllis*; 2) cinq espèces holarctiques: *Baetis bicaudatus*, *B. bundyae*, *Ephemerella mucronata*, *Metretopus borealis* et *Siphonurus alternatus*; 3) quatre espèces à répartition transcontinentale: *Baetis tricaudatus*, *Leptophlebia nebulosa*, *Paraleptophlebia debilis*, et *Procloeon ingens*, et finalement 4) de rares espèces à répartition surtout orientale qui atteignent au Yukon leur extension maximale vers l'ouest: *Heptagenia pulla* et *Siphloplecton prob. interlineatum*. Il n'y a pas d'élément endémique. Cette faune est très semblable en composition et en diversité à celle de l'Alaska, mais elle est beaucoup moins riche que celle de la région adjacente de la vallée du Mackenzie, dans les Territoires du Nord-Ouest. Elle paraît se composer principalement des espèces les plus robustes de la faune boréale occidentale avec l'addition de quelques éléments d'origine orientale et peu d'éléments vraiment arctiques. Cette faune appauvrie pourrait s'expliquer par les conditions climatiques et écologiques particulièrement rigoureuses qui forment des barrières zoogéographiques, mais il est aussi possible qu'un inventaire plus systématique révèle une faune beaucoup plus riche qu'il n'apparaît actuellement.

## Introduction

There has been only one systematic study of mayflies (Ephemeroptera) in the Yukon Territory by Cobb et al. (1995) in Kluane National Park. There are also 2 series of collections of nymphs, one from the Porcupine and Mackenzie River drainages as part of pre-impact studies related to proposed pipeline and highway developments (Brunskill et al. 1973; Wiens et al. 1975), and the other assembled for a study of classification of northwestern streams and rivers (Corkum and Ciborowski 1988; Corkum 1989). A few rare other records are scattered through the literature (e.g. Harper and Harper 1981). Thus, the opportunity to study even the limited collections gathered during the "Insect Fauna of the Yukon Project" was most welcome.

We are able to present a first annotated list of the mayflies of the Yukon, together with comments on some probable additional species to be expected, as well as a preliminary discussion of the zoogeography of the fauna.

### Material Examined

The specimens newly reported on here were collected during the early stages of the project (1979–1981) by teams from the University of British Columbia and the Royal Ontario Museum. All material is deposited in the entomological collections of these institutions.

The material consisted exclusively of adults preserved in alcohol. In mayflies, only male imagines can generally be identified with confidence; the identification of other stages (male subimagines and all females) is often tentative except by association, and some identification problems were encountered as mentioned below. The species were clearly referable to existing Nearctic taxa, but the extension of these species into the eastern Palaearctic region has never been systematically explored. The fauna of the Russian Far East is still imperfectly known (Levanidova 1964, 1968, 1972; Bajkova 1979), but appears to be dominated by many of the same genera as that of northwestern North America. The species, however, have never been critically compared.

### Annotated List of Yukon Species

The families are listed in alphabetical order, but the family definitions follow McCafferty (1996). Locality records are grouped according to the 20 ecogeographical regions identified in Scudder (1997) and represented on the map (Fig. 1). Records from the literature, when noteworthy, have been integrated into the list. Collections of subimagines are marked with parentheses.

#### Family Ameletidae

A small family (33 spp.) of fast-swimming species occurring in multispecific assemblages in small streams, particularly in mountainous areas. They feed on fine detritus and algae (Edmunds and Waltz 1996; Zloty 1996).

##### 1. *Ameletus* sp.

*Distribution:* Unknown.

*Yukon records:* Porcupine Plain (4): Bluefish R., Porcupine drainage (Wiens et al. 1975). St. Elias Mountains (16): Lewes Creek, (1 ♀), 27 June 1981.

*Biological information:* The nymphs inhabit small fast-flowing mountain streams and occasionally clean cold lake margins (Edmunds et al. 1976). Pritchard and Zloty (1994) investigated the life histories of two Alberta species (*A. celer* McDunnough and *A. similior* McDunnough) and found them to be complex and variable, with long egg diapauses and total cycles of 1–3 years.

*Taxonomic notes:* *Ameletus validus* McDunnough is reported from Alaska (Edmunds et al. 1976; Zloty 1996) and *A. prob. sparsatus* McDunnough from the Mackenzie mainstem (Wiens et al. 1975). *Ameletus subnotatus* Eaton and *A. inopinatus* Eaton are other possible species (Zloty 1996).

#### Family Baetidae

This is a family containing more than 140 species in North America, including many common ones. The nymphs are clingers and rapid swimmers that live in a wide variety of aquatic habitats, both lotic and lentic, where they feed on detritus and attached algae (Edmunds and Waltz 1996). Their life cycles are quite flexible and often multivoltine (Clifford 1982).

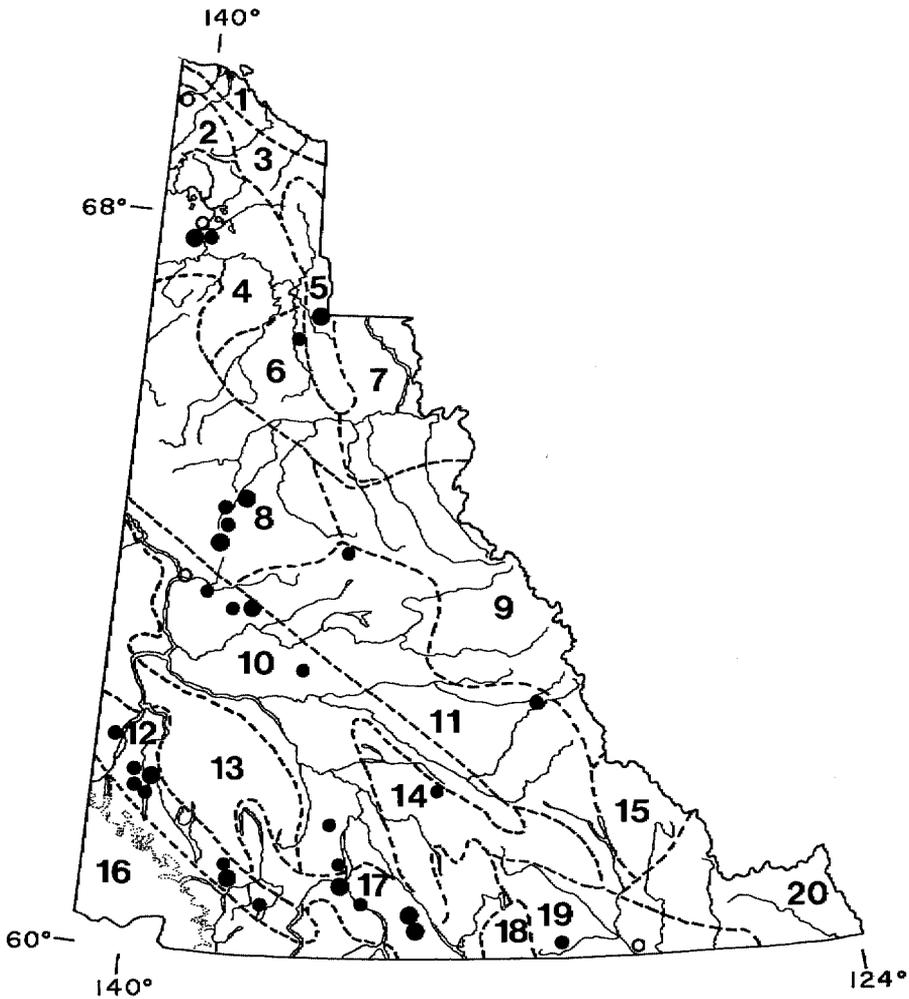


FIG. 1. Map of the Yukon showing the main river system and the 20 ecogeographic regions of Scudder (1997). The dots represent the sampling areas, the larger dots indicate multiple sites in the same area, and the open dots, literature citations.

## 2. *Acentrella insignificans* (McDunnough)

*Distribution:* This species possesses a wide distribution in western North America south to Arizona and New Mexico (Mohihara and McCafferty 1979).

*Yukon records:* Ogilvie Mountains (8): Dempster Hwy. km 97, marsh, 1•, 7 August 1980; Dempster Hwy. km 103, ∞, ••, 5 August 1980.

*Biological information:* A species living in a variety of stream and river situations.

*Taxonomic notes:* The species had not yet been recorded from the Yukon, although McCafferty (1985) suspected that the *Baetis* (now *Labiobaetis*) *propinquus* (Walsh) listed from Yukon (Caribou Bar Cr., Porcupine drainage) by Wiens et al. (1975) was "possibly misidentified *Baetis insignificans* McDunnough".

### 3. *Baetis bicaudatus* Dodds

*Distribution:* A common Cordilleran species recently recorded in Yukon and the Northwest Territories by Cobb et al. (1995). It is also known from Alaska and Siberia (Miller 1987; McCafferty 1994).

*Yukon records:* St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* A species inhabiting fast streams, where it generally produces two generations per year (Pearson and Kramer 1972).

### 4. *Baetis bundyae* Lehmkuhl (Frontispiece)

*Distribution:* An Holarctic species, *Baetis bundyae* is common throughout the northern tundra (Lehmkuhl 1973a; Cobb and Flannagan 1980; Harper and Harper 1981; Cobb et al. 1995; McCafferty 1994) and its distribution does not extend below 60°N. It was until recently considered to be a subspecies of the Palaearctic *Baetis macani* Kimmins.

*Yukon records:* British Mountains (2): Firth R. (Harper and Harper 1981). Porcupine Plain (4): Cadrow L., 20 km E Old Crow, 2♂, 14 June 1981, and 5♂, 14 July 1981; Old Crow Flats, 6♂, (1♀), 23 July 1981. Ogilvie Mountains (8): Dempster Hwy. km 105, pond, 2♂, 1♀, 30 July 1979, ♂♂, 1♀, 21 July 1980.

*Biological information:* This is a species characteristic of arctic ponds (Lehmkuhl 1973a).

### 5. *Baetis tricaudatus* Dodds

*Distribution:* A common and abundant species (formerly known as *Baetis vagans* McDunnough) with a northern transcontinental distribution, recently recorded from the Yukon, the Northwest Territories (Cobb et al. 1995), and Alaska (Miller 1987; McCafferty 1994).

*Yukon records:* St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* A typically bivoltine species over most of its range (Corkum and Pointing 1979; Clifford 1982; Robinson et al. 1992).

### “*Baetis*” spp.

*Yukon records:* Richardson Mountains (5): Dempster Hwy. km 503, 1♀, 30 July 1980. Eagle Plain (6): Dempster Hwy. km 482, 2♀, 31 July 1980. Ogilvie Mountains (8): Dempster Hwy. km 105, 1♀, 6 July 1980; km 198, Ogilvie R., 1♀, 19 July 1980; Dempster Hwy. km 119, Blackstone R., 1♀, 11 August 1980. Yukon/Tintina (10): Klondike Hwy. km 562, Moose Cr. Campground, 1♀, 27 July 1979; Klondike Hwy. km 566, ♀♀, 7–8 August 1980. Shakwak Trench (12): Alaska Hwy., Glacier Cr.; (1♂), 16 July 1979, and (1♂), 22 June 1980; Donjek R., Alaska Hwy. (2♀), 23 June 1981. Pelly Mountains (14): Rose L., 1♀, 28 July 1981. Southern Lakes (17): Whitehorse, 2♀, 26 June 1981.

*Taxonomic notes:* These specimens, mainly females or subimagines, are not assignable to a species, but could belong to one or other of the species known to occur in northern latitudes (Cobb and Flannagan 1980). They indicate, nonetheless, the widespread distribution of *Baetis*-like mayflies in the Territory.

### 6. *Callibaetis ferrugineus hageni* Eaton

*Distribution:* *Callibaetis ferrugineus* (Walsh) is distributed over all of North America, except the southwest and the extreme north, the typical subspecies restricted to the northeast and *C. f. hageni* occurring in the west and the north. The Dempster Highway record below is probably the most northerly record for the species, and more or less at the treeline. The species is obviously widespread and common in the Territory.

*Yukon records:* Richardson Mountains (5): Dempster Hwy. km 517, pond, 1♀, (1♀), 17 July 1980. Eastern Plateaus (11): Dragon L., on North Canol Rd., 2♂, 1♀, 10–11 June 1981. Shakwak Trench (12): Alaska Hwy. km 1630, Pine Cr. Campground, ♂♂, 25 June 1981; Bear Cr., W of Haines Junction, 1♀, 25 June 1980; Kluane, Jenny L., 1♀, 16 July 1979. Pelly Mountains (14): Rose L., (3♂), (3♀), 6 June 1981. St. Elias Mountains (16): Haines Rd. at Dezadeash Campground, (1♀), 19 June 1980; Lewes L., 1♂, (1♀), 6 July 1980; Haines Jct, Pine Cr., ♂♂, (3♀), 25 June 1981. Southern Lakes (17): Kookatsoon L., Hwy. 2 km 153, 1♂, (1♀), 27 June 1981; Little Atlin L., 6♂, 2♀, 27 July 1979; Squanga L., Alaska Hwy. km 1368, (1♂), (1♀), 1 nymph, 28 June 1981; Whitehorse (Harper and Harper 1981, as *Callibaetis* cf. *coloradensis*).

*Biological information:* The species typically inhabits cold ponds and lakes (Jensen 1966).

*Taxonomic notes:* This is the species that was formerly known as *C. americanus* Banks which was combined with *C. ferrugineus* (Walsh) by Check (1982); McCafferty and Waltz (1990), however, retained both species which are now considered as conspecific subspecies.

### 7. *Procloeon ingens* (McDunnough)

*Distribution:* A widely distributed but infrequently collected Nearctic species known in both the east and the west. A new Yukon record.

*Yukon records:* Eastern Plateaus (11): Elsa, Halfway L., 1 ♂, 6 August 1980.

*Biological information:* Nothing is known of the biology of this species.

### *Procloeon* sp.

*Distribution:* The females and subimagines listed in the following records indicate a wide distribution of the genus which was previously recorded from the Yukon (Wiens et al. 1975) and Alaska (Edmunds et al. 1976). Recently Cobb et al. (1995) listed *Procloeon pennulatum* (Eaton) from Nahanni National Park in the adjacent Northwest Territories, a species which probably also occurs in the Yukon.

*Yukon records:* Porcupine Plain (4): Porcupine R., 3 ♀, 28 July 1981, and 1 ♀, 21 July 1981; Old Crow, 6 km E, 19 July 1981. Richardson Mountains (5): Dempster Hwy. km 503, (1 ♂), 30 July 1980. Ogilvie Mountains (8): Dempster Hwy. km 216, 1 ♀, 20 July 1980. Shakwak Trench (12): Koidern, 1 ♀, 22 July 1979. Southern Lakes (17): Yukon R. at Whitehorse, 1 ♀, 26 June 1981; Whitehorse (Harper and Harper 1981, as *Centroptilum* sp.).

*Biological information:* The nymphs inhabit a variety of slow-flowing or stagnant waters (Edmunds et al. 1976).

### 8. "*Pseudocloeon*" sp.

*Distribution:* Unknown.

*Yukon records:* Porcupine Plain (4): Caribou Bar Cr., Porcupine drainage (Wiens et al. 1975). Pelly Mountains (14): Rose L., 1 ♀, 28 July 1981.

*Taxonomic notes:* This could be the widely distributed *Acentrella turbida* (McDunnough) (previously *Pseudocloeon carolina* (Banks)), a species reported from the "Far North" (i.e. Alaska, Yukon, Northwest Territories) by McCafferty and Waltz (1990), but also common throughout the eastern part of the continent in streams and rivers (Edmunds et al. 1976).

Other species of Baetidae expected on the Arctic Coastal Plain of the Yukon include *Acentrella lapponica* Bengtsson and *Baetis foemina* McDunnough (McDunnough 1936), as well as *B. hudsonicus* Ide (Ide 1937), known from the continental tundra in the eastern Northwest Territories.

## Family Caenidae

This is a small but widely distributed group. The nymphs are sprawlers in streams, rivers and lakes where they feed on detritus on soft substrates (Edmunds and Waltz 1996).

### 9. *Caenis youngi* Roemhild

*Distribution:* A Cordilleran species recently recorded from the Yukon and the Northwest Territories by Cobb et al. (1995).

*Yukon records:* St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

### *Caenis* sp.

*Yukon records:* Porcupine Plain (4): Caribou Bar Cr., Porcupine drainage (Wiens et al. 1975).

*Taxonomic notes:* These unidentified nymphs could belong to any of the four species reported from the Western Provinces (Provonsha 1990), but more probably to the widespread *Caenis youngi* as above.

Also expected from the Yukon is *Brachycercus arcticus* Soldan described from Alaska (Soldan 1986; McCafferty 1994).

## Family Ephemerellidae

A family of small to medium-sized, typically brownish mayflies, with about 100 North American species especially in the north and west of the continent. Adults fly relatively strongly. Nymphs live in the clean waters of rapid streams or small lakes (Edmunds and Waltz 1996).

**10. *Drunella coloradensis* Dodds**

*Distribution:* A “boreal western North American species with a long latitudinal distribution” (Allen and Edmunds 1962), known from Alaska and the Yukon to New Mexico.

*Yukon records:* Shakwak Trench (19): Alaska Hwy. km 1666, Jarvis R., in loose boreal forest (1 ♂), 15 July 1979. Liard Plain (19): Watson L. (Allen and Edmunds 1962). St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* The species prefers cold and fast-flowing streams and rivers (Jensen 1966). Its life cycle has been described by Radford and Hartland-Rowe (1971) and Hawkins (1986).

**11. *Drunella doddsi* Needham**

*Distribution:* A species with a distribution very similar to that of the preceding species.

*Yukon records:* Liard Plain (19): Watson L. (Allen and Edmunds 1962). St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* The life cycle of *D. doddsi* has been studied in Alberta (Radford and Hartland-Rowe 1971) and Oregon (Hawkins 1986).

**12. *Drunella grandis flavitincta* (McDunnough)**

*Distribution:* The *Drunella grandis* complex of three subspecies has a geographical distribution approaching that of the two previous species; *D. g. flavitincta* represents the northernmost element, extending from Oregon into Alaska along the Pacific Coast.

*Yukon records:* Liard Plain (19): Watson L. (Allen and Edmunds 1962).

*Biological information:* This species often inhabits the same streams as *D. coloradensis* but prefers the warmer sections (Jensen 1966).

**13. *Ephemerella mucronata* (Bengtsson)**

*Distribution:* This Holarctic species has a northern transcontinental distribution in the Palaearctic region. It has also been recorded from the western part of the Northwest Territories (Reindeer Depot, Norman Wells; Harper and Harper 1981), but it does not appear to extend further east.

*Yukon records:* Porcupine Plain (4): Rampart House (Harper and Harper 1981).

*Biological information:* In the Swiss Alps, the species inhabits mountain streams at mid-altitudes (Studeman et al. 1992).

A number of additional species of Ephemerellidae probably occur in the Territory; the most likely are: *Ephemerella aurivillii* Bengtsson, a common Holarctic species widespread throughout the northern Nearctic region, though apparently with a disjunct distribution, but recorded from both eastern and western Canada and from Alaska (Allen 1968; Edmunds et al. 1976; Harper and Harper 1981; McCafferty 1985); *Ephemerella inermis* Eaton (this is more probably *E. infrequens* McDunnough according to Johnson (1978) and McCafferty (1994)) and *Serratella tibialis* (McDunnough), recorded from Alaska and the Northwest Territories, but with a wide Cordilleran distribution reminiscent of those of the *Drunella* spp. above (Allen 1968; Edmunds et al. 1976; McCafferty 1985; Cobb et al. 1995); *Ephemerella lacustris* Allen and Edmunds described from Yellowstone Lake (Wyoming), and later reported from Alaska (McCafferty 1985).

**Family Heptageniidae**

This is a family of medium-sized mayflies with more than 130 North American species. Typical heptageniid nymphs are dark-coloured, flattened sprawlers; most species live in streams but some live in rivers and ponds. They scrape the Aufwuchs off stones (Edmunds and Waltz 1996).

**14. *Cinygmula mimus* (Eaton)**

*Distribution:* A widespread boreal species in the United States. Also known from British Columbia and Alberta (McDunnough 1924; Scudder 1975); a new record for the Yukon.

*Yukon records:* Ogilvie Mountains (8): Dempster Hwy. km 220, Ogilvie R., 1 ♂, 13 June 1980. Yukon/Tintina (10): Moose Cr. at Campground, 1 ♂, 19 June 1979. Pelly Mountains (14): Rose L., 1 ♂, 28 July 1981. Southern Lakes (17): Alaska Hwy. km 1251, at Morley R., 1 ♂, 13 June 1980.

*Biological information:* The species develops in small to medium mountain streams (Jensen 1966).

**15. *Cinygmula par* (Eaton)**

*Distribution:* Another widespread Cordilleran species, common in British Columbia (Scudder 1975); recorded by Harper and Harper (1981) from Alaska. A new record for the Yukon.

*Yukon records:* Yukon/Tintina (10): Klondike Hwy. km 566, ♂♂, ♀, 7–8 August 1980.

*Biological information:* The species inhabits fast-flowing mountain streams (Jensen 1966).

**16. *Cinygmula ramaleyi* (Dodds)**

*Distribution:* A common Cordilleran species previously recorded from Alberta (McDunnough 1924) and British Columbia (Scudder 1975); a new record for the Yukon.

*Yukon records:* Yukon/Tintina (10): Klondike Hwy. km 562, Moose Cr. Campground, 1♂, 27 July 1979.

*Biological information:* The ecology of the species is similar to that of its 2 congeners (Jensen 1966). Its life cycle has been studied by Hartland-Rowe (1964) and Radford and Hartland-Rowe (1971).

**17. *Epeorus grandis* (McDunnough)**

*Distribution:* A boreal species in the Pacific Northwest of the United States, also recorded in Alberta and British Columbia and the Northwest Territories (Scudder 1975; Edmunds et al. 1976; Cobb et al. 1995); a new record for the Yukon.

*Yukon records:* Pelly Mountains (14): Rose L., 2♂, 28 July 1981.

*Biological information:* This species inhabits cold mountain streams and rivers (Jensen 1966).

**18. *Epeorus longimanus* (Eaton)**

*Distribution:* “The most widely distributed Rocky Mountain species” in its genus, it was recorded from every western state, as well as from Alberta and British Columbia (Edmunds and Allen 1964) and the Northwest Territories (Cobb et al. 1995); a new record for the Yukon.

*Yukon records:* Yukon/Tintina (10): Klondike Hwy. km 562, Moose Cr. Campground, 1♀, 27 July 1979.

*Biological information:* This species develops in the colder reaches of small to medium mountain streams (Jensen 1966). Its biology has been studied by Hartland-Rowe (1964) in Alberta and by Lehmkuhl (1968) in Oregon.

**19. *Heptagenia pulla* (Clemens)**

*Distribution:* A common and widespread species in temperate and boreal eastern Canada, its distribution extends up into the Mackenzie Valley (Harper and Harper 1981) and the Yukon (Cobb et al. 1995).

*Yukon records:* Porcupine Plain (4): Old Crow, 6 km E, 2♂, 19 July 1981. St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* *H. pulla* occurs in both streams and large lakes (Flowers and Hilsenhoff 1975).

**20. *Rhithrogena futilis* McDunnough**

*Distribution:* A widespread Cordilleran species, recorded from Alberta (McDunnough 1928), British Columbia (Scudder 1975) and Alaska (Harper and Harper 1981; McCafferty 1985).

*Yukon records:* Porcupine Plain (4): Old Crow, 9 km W Black Fox Cr., 1♂, 15 July 1981; Old Crow, Porcupine R., 1♂, 10 July 1981; Rampart House (Harper and Harper 1981); Porcupine River and its tributaries, Bluefish R., Caribou Bar Cr., Driftwood R., Old Crow R. (Wiens et al. 1975). Pelly Mountains (14): Rose L., 1♂, 28 July 1981.

*Biological information:* The species has a boreal distribution, but little is known of its biology (Jensen 1966).

**21. *Rhithrogena undulata* Banks**

*Distribution:* A species widely distributed in the western states of the United States, recorded by Cobb and Flannagan (1980) and Cobb et al. (1995) from the Mackenzie Valley.

*Yukon records:* Southern Lakes (17): Whitehorse (Harper and Harper 1981).

*Biological information:* In Idaho the species develops in large silted streams in the boreal zone (Jensen 1966). Its life cycle has been studied in Wisconsin by Flowers and Hilsenhoff (1978).

Additional species of Heptageniidae expected from the Yukon include: *Cinygma lyriformis* (McDunnough) described from Alberta, but also recorded from Alaska

(Lehmkuhl 1979; McCafferty 1985; Flowers 1986); *Cinygmula subaequalis* (Banks), a widespread eastern species, reported from Alaska by McCafferty (1985), but otherwise unknown in the west; and *Heptagenia solitaria* McDunnough, a widespread Cordilleran species, recorded from Alaska (Koss 1970); the Holarctic *Nixe simplicioides* (McDunnough) is a likely candidate, but thought no longer to occur there, eliminated by postglacial climate (Flowers 1986).

### Family Leptophlebiidae

Leptophlebiids are widely distributed in North America. The nymphs are active swimmers and colonize still or slow-flowing waters. They feed on fine to coarse detritus (Edmunds and Waltz 1996).

#### 22. *Leptophlebia nebulosa* (Walker)

*Distribution:* A transcontinental northern Nearctic species in both the temperate and boreal zones. Also recorded from Swim Lake, Yukon, by Harper and Harper (1981).

*Yukon records:* Shakwak Trench (12); Haines Jct., Pine Cr., 1 ♂, 25 June 1981.

*Biological information:* The species lives in the littoral areas of lakes and on the margins of slow streams.

#### *Leptophlebia* sp.

*Yukon records:* Yukon/Tintina (10): Little Fox L., 1 ♀, 3 July 1980. Eastern Plateaus (11): Dragon L., North Canol Rd., (♂ ♂), (♀ ♀), 10 June 81. Southern Lakes (17): Atlin Rd. km 26 at Snafu L. Campground, (2 ♀), 28 June 1981; Snafu Cr., (1 ♂), 1 ♀, 29 June 1981; Quiet L., km 98 on Canol Rd., (1 ♀), 16 July 1980.

*Taxonomic notes:* These females and subimagines could belong to the previous species or perhaps to the even more common *Leptophlebia cupida* (Say).

#### 23. *Paraleptophlebia debilis* (Walker)

*Distribution:* Another common transcontinental species (Edmunds et al. 1976); its occurrence in the Yukon is not unexpected.

*Yukon records:* Southern Lakes (17): Snafu Cr., 1 ♂, 22 July 1981.

*Biological information:* A species of wide ecological valency in streams (Lehmkuhl and Anderson 1971).

#### *Paraleptophlebia* sp.

*Yukon records:* St. Elias Mountains (16): Alaska Hwy. km 1666, Jarvis R., (1 ♀), 15 July 1979.

*Taxonomic notes:* This specimen could belong to a number of species, including the one above; Harper and Harper (1981) recorded *P. moerens* (McDunnough) from Reindeer Depot in the Mackenzie Valley. The genus is also reported from Alaska (Edmunds et al. 1976).

### Family Metretopodidae

A small family (9 spp.) of fast-swimming nymphs which inhabit both streams and lakes and feed on invertebrates and detritus (Edmunds and Waltz 1996).

#### 24. *Metretopus borealis* Eaton

*Distribution:* A trans-Holarctic species, common throughout the Canadian subarctic and boreal regions (Berner 1978) where it is locally abundant. Nymphs have been recorded from Alaska (Berner 1978), but McCafferty (1994) assigns them to *M. alter* Bengtsson.

*Yukon records:* Yukon/Tintina (10): Dawson (Harper and Harper 1981).

*Biological information:* *Metretopus borealis* inhabits slow-moving streams and lake margins (Edmunds et al. 1976).

#### 25. *Siphloplecton* sp.

*Distribution:* Unknown.

*Yukon records:* Porcupine Plain (4): Caribou Bar Cr., Porcupine drainage (Wiens et al. 1975).

*Biological information:* The species lives in slow streams and the littoral area of lakes; the life cycle of *S. basale* (Walker) from Alberta has been studied by Clifford (1976).

*Taxonomic notes:* The nymphs recorded above are probably *S. interlineatum* (Walsh), a species recorded throughout the boreal zone in the adjacent Northwest Territories and the north-central United States (Bernier 1978).

### Family Siphonuridae

Siphonurid mayflies are widely distributed in North America (25 spp.). The nymphs are streamlined, and occur chiefly in fast-flowing streams and rivers, where they feed on detritus; a few species are predaceous (Edmunds and Waltz 1996).

#### 26. *Siphonurus alternatus* (Say)

*Distribution:* An Holarctic species, common in the east; recorded from Reindeer Depot, Northwest Territories by Harper and Harper (1981).

*Yukon records:* Porcupine Plain (4): Porcupine R., 2♂, 21–28 July 1981.

*Biological information:* The species inhabits slow streams, ponds and lake margins. Its life cycle has been studied by Barton (1980).

#### 27. *Siphonurus occidentalis* Eaton

*Distribution:* A widespread boreal species in the western United States, also reported from Alberta (McDunnough 1928), British Columbia (Scudder 1975), and the Yukon (Cobb et al. 1995).

*Yukon records:* Porcupine Plain (4): Rampart House, (Harper and Harper 1981). Pelly Mountains (14): Rose L., (1♂), 28 July 1981. St. Elias Mountains (16): Kluane National Park (Cobb et al. 1995).

*Biological information:* *S. occidentalis* develops in slow rivers and streams and cool ponds (Jensen 1966). Its life cycle has been described by Lehmkuhl (1973b).

#### 28. *Siphonurus phyllis* McDunnough

*Distribution:* A boreal species recorded from both eastern and western Canada (Edmunds et al. 1976); a new record for the Yukon, although already known from Yellowknife, Northwest Territories (Harper and Harper 1981).

*Yukon records:* Porcupine Plain (4): Klondike Hwy. km 476, 10 km N Pelly Crossing, 2♂, 3♀, 23 July 1979. Shakwak Trench (12): Koidern, (1♂), (2♀), 22 July 1979.

#### 29. *Siphonurus* sp.

*Distribution:* Unknown.

*Yukon records:* Porcupine Plain (4): 28 km N Old Crow, (1♂), 1 nymph, 12 July 1981.

*Taxonomic notes:* A species keying to *Siphonurus autumnalis* McDunnough in Needham et al.'s (1935) key. It appears to differ in genitalic characters from McDunnough's (1931) original description, and may therefore prove to be a new species; a male imago would be needed for confirmation.

#### 30. *Parameletus* sp.

*Distribution:* Unknown.

*Yukon records:* Porcupine Plain (4): Old Crow, 6 km E, 1♀, 3 July 1981. Ogilvie Mountains (8): Dempster Hwy. mi 150, (1♀), 22 June 1980.

*Biological information:* The species develop in swamps, forest pools (Jensen 1966) and flooded lake and river margins.

*Taxonomic notes:* The above records are probably referable either to *Parameletus chelifer* Bengtsson, an Holarctic species recorded from Alaska and adjacent Northwest Territories (Harper and Harper 1981), or to *P. columbiae* McDunnough from Alaska (Koss 1970), though this latter record has not been confirmed by McCafferty (1985, 1994).

## Additional Species Expected from the Yukon

Species noted in the accounts above that may also occur in the Yukon are listed here for reference.

### Family Ameletidae

31. *Ameletus subnotatus* Eaton

32. *Ameletus inopinatus* Eaton

33. *Ameletus validus* McDunnough or *A. prob. sparsatus* (McDunnough) (cf. species 1)

**Family Baetidae**

- 34. *Acentrella turbida* (McDunnough)
- 35. *Acentrella lapponica* Bengtsson
- 36. *Baetis foemina* McDunnough
- 37. *Baetis hudsonicus* Ide
- 38. *Procloeon pennulatum* Eaton

**Family Caenidae**

- 39. *Brachycercus arcticus* Soldan

**Family Ephemerellidae**

- 40. *Ephemerella aurivillii* Bengtsson
- 41. *Ephemerella inermis* Eaton or *E. infrequens* McDunnough
- 42. *Ephemerella lacustris* Allen and Edmunds
- 43. *Serratella tibialis* (McDunnough)

**Family Heptageniidae**

- 44. *Cinygma lyriformis* (McDunnough)
- 45. *Cinygmula subaequalis* (Banks)
- 46. *Heptagenia solitaria* McDunnough
- 47. *Nixe simplicioides* (McDunnough)

**Family Leptophlebiidae**

- 48. *Leptophlebia cupida* (Say)
- 49. *Paraleptophlebia moerens* (McDunnough)

**Family Metretopodidae**

- 50. *Metretopus alter* Bengtsson

**Family Siphonuridae**

- 51. *Parameletus chelififer* Bengtsson or *P. columbiae* McDunnough (cf. species 30).

**Discussion**

Despite rather haphazard sampling, an interesting series of mayflies was obtained by this collecting in the Yukon. How representative it is of the Yukon fauna as a whole is, however, impossible to assess. Most of the collection sites are along the highways and are generally concentrated in only a few of the 20 ecogeographic regions recognized by Scudder (1997). The areas that are best represented in the data are the Porcupine Plain (area 3) near Old Crow [also the site of the survey by Wiens et al. 1975], the Ogilvie Mountains (area 8) along the Dempster Highway, and the Shakwak Trench (area 12) and the Southern Lakes Area (area 17) along the Alaska Highway. There was little sampling in the far north, the eastern slopes and the mountainous areas. Nevertheless, the regions that were sampled represent some of the major drainages of the Territory.

At least 30 taxa of mayflies, most of them identified to species, have been collected from the Yukon Territory (Table 1); this compares with the approximately 2 dozen taxa listed by McCafferty (1985, 1994) from Alaska. An extensive survey of the Alaskan stream fauna (unfortunately only at the family level) by Oswood (1989) indicates that mayflies represent numerically about 10% of the stream benthos, and that the dominant families are, in decreasing order, Baetidae, Heptageniidae, Siphonuridae (s. lat., including Ameletidae), Ephemerellidae, and Leptophlebiidae, a situation similar to that we observe here.

By comparison, 54 taxa have been recorded from the Mackenzie drainage (Wiens et al. 1975), but only 9 from the eastern Northwest Territories (= District of Keewatin and Boothia Peninsula) (Cobb and Flannagan 1980). The relative richness of the Mackenzie Valley is

due no doubt to its direct links to more southerly drainages and its more clement meteorological conditions; indeed, Harper and Harper (1981) already observed the large number of typically eastern Nearctic species whose distribution extends in a northwestern direction into the Mackenzie drainage; these species probably migrated westwards through the "West Agassiz" route when the Mackenzie River system drained to the southeast into Lake Agassiz (Flannagan and Flannagan 1984). As well, Allen's (1990) distribution patterns show many species extending from the western United States along the Cordillera into the Mackenzie drainage, for instance his "northwestern" (71 species), "Rocky Mountain" (11 species), and "northwest and Rocky Mountain" (8 species) patterns. This richness in species appears to decrease rapidly westwards, and only 15 taxa are reported from the Porcupine drainage, flowing west into the Yukon River (Wiens et al. 1975; Cobb and Flannagan 1980).

The Yukon mayfly fauna as currently known contains 4 zoogeographical elements:

1. The widespread Cordilleran species, which form the majority of the fauna, have geographical distributions which run along the western mountain ranges and extend northward into Alaska ("widespread western" in Allen's (1990) classification); such are *Acentrella insignificans* (2), *Callibaetis ferrugineus hageni* (6), *Caenis youngi* (9), *Drunella* spp. (10–12), *Cinygmula* spp. (14–16), *Epeorus longimanus* (18), *Rhithrogena futilis* (20), *Siphonurus occidentalis* (27), and *S. phyllis* (28).

2. A small number of Holarctic species, most of them restricted in North America to the northernmost part of the continent where they extend from west to east: these are *Baetis bicaudatus* (3), *B. bundyae* (4), *Ephemerella mucronata* (13), *Metretopus borealis* (24), and *Siphonurus alternatus* (26). They do not fall readily into any of Allen's (1990) patterns, though *B. bundyae* (as *B. macani*) was included in his "Nearctic pattern". They correspond to Flannagan and Flannagan's (1984) "north transcontinental" fauna. *Ephemerella mucronata* does not appear to extend east of the Mackenzie Valley, and is the only element of the fauna to have a Beringian distribution in North America.

3. A few species of transcontinental distribution which reach their northernmost extension in the Yukon and/or Alaska ("pancontinental pattern" of Allen (1990) and "south transcontinental" of Flannagan and Flannagan (1984)): *Baetis tricaudatus* (5), *Procloeon ingens* (7), *Leptophlebia nebulosa* (22) and *Paraleptophlebia debilis* (23).

4. The westernmost extension of a northeastern Nearctic fauna, typically distributed over eastern Canada and the northeastern United States, generally over the eastern glaciated areas ("northeast" pattern of Allen (1990)); the only species included are *Heptagenia pulla* (19) and *Siphloplecton* prob. *interlineatum* (25).

There is no endemic element; the status of *Siphonurus* sp. (cf. *autumnalis*) (29) needs to be clarified before anything more can be said about it. We have found no evidence of unexpected species with widely disjunct distributions, as did McCafferty (1985) in Alaska (e.g. *Ephemerella lacustris* and *Cinygmula subaequalis*). The fact that parts of the Yukon and of Alaska have remained unglaciated during the last glaciations is used by McCafferty to explain the existence of these disjunct elements. Such species are of great potential zoogeographical interest, but more information is needed on their identity and distribution before the significance of their presence can be assessed.

The relatively larger contribution of western elements as compared to eastern indicates that the Yukon is clearly within the western zoogeographical province. The eastern influence, dominant in the Prairies (Lehmkuhl 1980) and still prevalent in the Mackenzie Valley (Harper and Harper 1981), is considerably weakened. The mountain ranges of the eastern Yukon and the increasingly harsh weather conditions are thus effective barriers to colonization by species of eastern and southeastern origin.

TABLE 1. Systematic checklist and distributions of species currently known from the Yukon. Classification follows McCafferty (1996). Species records are indicated by +; records in parentheses indicate the presence of the corresponding genus but no confirmed record of the species.

Abbreviations: PAL, Palearctic region; AK, Alaska; WUS, Western States of the United States; WCP, Western Canadian Provinces; NWT, Northwest Territories; ENA, Eastern North America.

Species (Species number)	PAL	AK	WUS	WCP	NWT	ENA
Suborder Pisciformia						
Family Ameletidae						
<i>Ameletus</i> sp. (1)						
Family Baetidae						
<i>Acentrella insignificans</i> (McDunnough) (2)		+	+	+		
<i>Baetis bicaudatus</i> Dodds (3)			+	+	+	
<i>Baetis bundyae</i> (Lehmkuhl) (4)	+	+			+	
<i>Baetis tricaudatus</i> Dodds (5)			+	+	+	+
<i>Callibaetis ferrugineus hageni</i> Eaton (6)		(+)	+	+	+	
<i>Procloeon ingens</i> (McDunnough) (7)			+	+		+
" <i>Pseudocloeon</i> " sp. (8)						
Family Metrotopodidae						
<i>Metretopus borealis</i> Eaton (24)	+		+	+	+	+
<i>Siphloplecton</i> sp. (25)						
Family Siphonuridae						
<i>Parameletus</i> sp. (30)						
<i>Siphonurus alternatus</i> (Say) (26)	+			+	+	+
<i>Siphonurus occidentalis</i> Eaton (27)			+	+	+	
<i>Siphonurus phyllis</i> McDunnough (28)				+		+
<i>Siphonurus</i> sp. (29)						
Suborder Setisura						
Family Heptageniidae						
<i>Cinygmula mimus</i> (Eaton) (14)			+	+		
<i>Cinygmula par</i> (Eaton) (15)		+	+	+		
<i>Cinygmula ramaleyi</i> (Dodds) (16)			+	+	+	
<i>Epeorus longimanus</i> (Eaton) (18)		+	+	+	+	
<i>Epeorus (Ironopsis) grandis</i> McDunnough (17)			+	+	+	
<i>Heptagenia pulla</i> (Clemens) (19)				+	+	+
<i>Rhithrogena futilis</i> McDunnough (20)		+	+	+		
<i>Rhithrogena undulata</i> Banks (21)			+		+	
Suborder Rectracheata						
Family Leptophlebiidae						
<i>Leptophlebia nebulosa</i> (Walker) (22)			+	+	+	+
<i>Paraleptophlebia debilis</i> (Walker) (23)		(+)	+	+	(+)	+
Family Ephemerellidae						
<i>Drunella coloradensis</i> Dodds (10)		+	+	+	+	
<i>Drunella doddsi</i> Needham (11)		+	+	+	+	
<i>Drunella grandis flavitincta</i> (McDunnough) (12)		+	+	+	+	
<i>Ephemerella mucronata</i> (Bengtsson) (13)		+			+	
Family Caenidae						
<i>Caenis youngi</i> Roemhild (9)			+	+	+	

These results concur with what is generally known of arctic faunas, namely their dominance by few but widely distributed species and the large percentage of Holarctic species (Downes 1962). The number of Holarctic elements in the Yukon fauna is lower than expected, but this could increase when the arctic regions are better sampled, and when the

faunas of both sides of the Pacific Rim are critically compared. The situation, however, appears to be very similar in Alaska (McCafferty 1985, 1994), where detailed collections are also still scanty.

As many of the Holarctic species are confined to northern latitudes, and because their distribution appears to be centred in the west rather than the east, it has generally been hypothesized that they have colonized North America from northwestern refugia (Lehmkuhl 1980), though Flannagan and Flannagan (1984) suggest a variety of migration routes from the east, the west or the south. Cobb and Flannagan (1980) also suggest earlier (pre-glacial) colonization through a north Atlantic route for some of them; there is little evidence of this at present. Species of special interest in this context are those that appear to be confined to the Northwest Territories, never having been collected either eastwards or westwards; such are *Baetis foemina*—which extends into the Mackenzie drainage (Moore 1977)—and *Baetis hudsonicus*.

Cobb and Flannagan (1980) relate the low diversity of the mayfly faunas of northern latitudes to the difficulty of adult dispersal in cold weather conditions; colonization is therefore thought to be mainly through aquatic routes in the nymphal stage. This reliance on connections between drainage systems for dispersal may be a partial explanation of the decreased diversity, but habitat conditions (treeline, winter icing, availability of resources) are certainly involved (Harper 1981; Danks 1990). Corkum and Ciborowski (1988) showed a high correlation between environmental variables such as river size, velocity, slope, latitude, and conductivity, and mayfly distributions.

The majority of species are of western origin, and typically are distributed along the Cordillera and the western mountain ranges. The taxa collected up to now in the Yukon are the hardier elements of this fauna; in the western United States, these species typically are widespread and generally inhabit the boreal zone above 1200–1500 m. Both lotic and lentic species are involved, but the majority of species inhabit running waters; the major stagnant-water elements are *Callibaetis ferrugineus hageni*, *Leptophlebia* spp., *Metretopus borealis* and *Siphloplecton* sp. (6, 22, 24, 25), but all, except perhaps the first, can be found in slow streams and stream pools. Conversely, many of the lotic species can colonize cold lakes, particularly rocky shores.

The data presented here are yet too scanty for generalizations and the casual collections can in no way allow any discussion of species distribution within the Yukon Territory. Corkum (1989) has recently presented a classification of northwestern streams based on benthic invertebrate assemblages. Yukon streams fall within her categories “d” and “e”; the former prevails over most of the Yukon Territory and is characterized by an abundance of Oligochaeta; the mayflies belong mainly to the families Baetidae and Heptageniidae, with some Ephemerellidae, Siphonuridae (s. lat.), Caenidae (and Tricorythidae), the same groups as in our list. The less common “e” group of streams is characterized by a dominance of Rhyacophilidae (Trichoptera) and Systellognatha (Plecoptera); the mayflies belong, in decreasing importance, to the families Heptageniidae, Baetidae, Ephemerellidae and Siphonuridae (s. lat.). These results are but a preliminary insight into the fauna of a large and diverse territory. The Yukon is potentially a very interesting region for a study of the zoogeography of mayflies, as it sits at the junction of the eastern, western, and arctic faunas. It is particularly important because it may have played a role in the postglacial recolonization of northern latitudes. More extensive collecting will, however, be needed before any serious investigation of these relationships can be undertaken.

## Acknowledgements

We are grateful to Drs. G.G.E. Scudder, University of British Columbia and G.B. Wiggins of the Royal Ontario Museum who asked us to participate in this project and made their collections available to us. We thank all those who collected the mayflies, although they were interested primarily in other groups of insects: R.A. Cannings, S.G. Cannings, C.S. Guppy, G.G.E. Scudder, L. Vasington of the U.B.C. team, and R. Jaagumagi and other anonymous members of the R.O.M. field party.

## References

- Allen, R.K. 1968. New species and records of *Ephemerella* (*Ephemerella*) in western North America (Ephemeroptera: Ephemerellidae). *J. Kans. ent. Soc.* 41:557–567.
- 1990. Distribution patterns of North and Central American mayflies (Ephemeroptera). pp. 155–167 in I.C. Campbell (Ed.), *Mayflies and Stoneflies, Life Histories and Biology*. Kluwer Academic Publishers, Dordrecht. 366 pp.
- Allen, R.K. and G.F. Edmunds Jr. 1962. A revision of the genus *Ephemerella* (Ephemeroptera, Ephemerellidae). V. The subgenus *Drunella* in North America. *Misc. Publs ent. Soc. Am.* 3:147–186.
- Bajkova, O.J. 1979. A comparative review of the mayfly fauna of Siberia and of the Soviet Far East (In Russian, English Summary). pp. 15–20 in K. Pasternak and R. Sowa (Eds.), *Proc. 2nd Int. Conf. on Ephemeroptera*. Polska Akad. Nauk, Warsaw-Krakow. 312 pp.
- Barton, D.R. 1980. Observations on the life histories and biology of Ephemeroptera and Plecoptera in northeastern Alberta. *Aquat. Insects* 2:97–111.
- Berner, L. 1978. A review of the mayfly family Metretopodidae. *Trans. Am. ent. Soc.* 104:91–137.
- Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R. Wageman. 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Canada Task Force, North. Oil Develop. Envir. Comm., II. Report 73-41. 345 pp.
- Check, G.R. 1982. A revision of the North American species of *Callibaetis* (Ephemeroptera: Baetidae). Unpubl. Ph.D. thesis, Univ. Minnesota. 157 pp. [University Microfilms no. 8308030]
- Clifford, H.F. 1976. Observations on the life cycle of *Siphloplecton basale* (Walker) (Ephemeroptera; Metretopodidae). *Pan-Pacif. Ent.* 52:265–271
- 1982. Life cycles of mayflies (Ephemeroptera), with special reference to voltinism. *Quaest. ent.* 18:15–90.
- Cobb, D.G. and J.F. Flannagan. 1980. The distribution of Ephemeroptera in northern Canada. pp. 155–166 in J.F. Flannagan and K.E. Marshall (Eds.), *Advances in Ephemeroptera Biology*. Plenum Publishing Corp., New York. 552 pp.
- Cobb, D.G., J.F. Flannagan, P.M.L. Flannagan, and R.D. Wickstrom. 1995. Collections of Ephemeroptera from Kluane National Park, Yukon Territory, and Nahanni National Park, Northwest Territories, Canada. pp. 177–184 in L.D. Corkum and J.J.H. Ciborowski (Eds.), *Current Direction in Research on Ephemeroptera*. Canadian Scholars' Press, Toronto. 345 pp.
- Corkum, L.D. 1989. Patterns of benthic invertebrate assemblages in rivers of northwestern North America. *Freshwat. Biol.* 21:191–205.
- Corkum, L.D. and J.J.H. Ciborowski. 1988. Use of alternative classifications in studying broad-scale distributional patterns of lotic invertebrates. *J. N. Am. benthol. Soc.* 7:167–179.
- Corkum, L.D. and P.J. Pointing. 1979. Nymphal development of *Baetis vagans* McDunnough (Ephemeroptera; Baetidae) and drift habits of large nymphs. *Can. J. Zool.* 57:2348–2354.
- Danks, H.V. 1990. Arctic insects: instructive diversity. pp. 444–470 in C.R. Harington (Ed.), *Canada's Missing Dimension: Science and History in the Canadian Arctic Islands*, vol II. Canadian Museum of Nature, Ottawa. 2 vols, 855 pp.
- Downes, J.A. 1962. What is an arctic insect? *Can. Ent.* 94:143–162.
- Edmunds, G.F., Jr. and R.K. Allen. 1964. The Rocky Mountain species of *Epeorus* (*Iron*) Eaton (Ephemeroptera: Heptageniidae). *J. Kans. ent. Soc.* 4:275–288.
- Edmunds, G.F., Jr. and R.D. Waltz. 1996. Ephemeroptera. Chap. 11 in R.W. Merritt and K.W. Cummins (Eds.), *An introduction to the aquatic insects of North America*. 3rd edition. Kendall-Hunt, Dubuque, Iowa. 862 pp.
- Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. *The Mayflies of North and Central America*. Univ. Minnesota Press, Minneapolis. 330 pp.
- Flannagan, P.M. and J.F. Flannagan. 1984. The post-glacial origin and present distribution of the mayflies (Ephemeroptera) of Manitoba, Canada. pp. 149–169 in V. Landa, T. Soldan, and M. Tonner (Eds.), *Proc. IVth Int. Conf. Ephemeroptera, Czechoslovak Acad. Sciences*. 418 pp.
- Flowers, R.W. 1986. Holarctic distributions of three taxa of Heptageniidae (Ephemeroptera). *Ent. News* 97:193–197.
- Flowers, R.W. and W.L. Hilsenhoff. 1975. Heptageniidae (Ephemeroptera) of Wisconsin. *Gt Lakes Ent.* 8:201–218.

- 1978. Life cycles and feeding habits of Wisconsin Heptageniidae (Ephemeroptera). *Hydrobiologia* 60:159–171.
- Harper, F. and P.P. Harper. 1981. Northern Canadian mayflies (Insecta; Ephemeroptera), records and descriptions. *Can. J. Zool.* 59:1784–1789.
- Harper, P.P. 1981. Ecology of streams at high latitudes. pp. 313–337 in M.A. Lock and D.D. Williams (Eds.), *Perspectives in Running Water Ecology*. Plenum Press, New York. 430 pp.
- Hartland-Rowe, R. 1964. Factors influencing the life histories of some stream insects in Alberta. *Verh. int. verein. theor. angew. Limnol.* 15:917–925.
- Hawkins, C.P. 1986. Variation in individual growth rates and population densities of Ephemerellid mayflies. *Ecology* 67:1384–1395.
- Ide, F.P. 1937. Descriptions of eastern North American species of Baetinae mayflies, with particular reference to the nymphal stages. *Can. Ent.* 69:219–231.
- Jensen, S.L. 1966. The mayflies of Idaho (Ephemeroptera). Unpubl. Ph.D. Thesis, Univ. Utah, Salt Lake City. 367 pp.
- Johnson, S.C. 1978. Larvae of *Ephemerella inermis* and *E. infrequens* (Ephemeroptera; Ephemerellidae). *Pan-Pacif. Ent.* 54:19–25.
- Koss, R.W. 1970. A list of the mayflies (Ephemeroptera) in the Michigan State University Entomology Museum. *Michigan Ent.* 3:98–101.
- Lehmkuhl, D.M. 1968. Observations on the life histories of four species of *Epeorus* in western Oregon (Ephemeroptera; Heptageniidae). *Pan-Pacif. Ent.* 44:129–137.
- 1973a. A new species of *Baetis* (Ephemeroptera) from ponds in the Canadian Arctic, with biological notes. *Can. Ent.* 105:343–346.
- 1973b. Adaptations to a marine climate illustrated by Ephemeroptera. pp. 33–38 in W.L. Peters and J.G. Peters (Eds.), *Proc. 1st Int. Conf. on Ephemeroptera*. E.J. Brill, Leiden. 312 pp.
- 1979. The North American species of *Cinygma* (Ephemeroptera: Heptageniidae). *Can. Ent.* 111:675–680.
- 1980. Temporal and spatial changes in the Canadian insect fauna: patterns and explanation, the Prairies. *Can. Ent.* 112:1145–1159.
- Lehmkuhl, D.M. and N.H. Anderson. 1971. Contributions to the biology and taxonomy of the *Paraleptophlebia* of Oregon (Ephemeroptera: Leptophlebiidae). *Pan-Pacif. Ent.* 47:85–93.
- Levanidova, I.M. 1964. On the geography of the aquatic fauna of the southern regions of the Far East (In Russian). *Bull. Pacif. Sci. Inst. Fish. Oceanogr.* 55:175–195.
- 1968. Benthos of the River Amur (ecologo-faunistic study) (In Russian). *Bull. Pacif. Sci. Inst. Fish. Oceanogr.* 64:181–289.
- 1972. The mayflies of Kamchatka (In Russian). *Bull. Pacif. Sci. Inst. Fish. Oceanogr.* 82:93–115.
- McCafferty, W.P. 1985. The Ephemeroptera of Alaska. *Proc. ent. Soc. Wash.* 87:381–386.
- 1994. Additions and corrections to the Ephemeroptera of Alaska. *Proc. ent. Soc. Wash.* 96:177.
- 1996. The Ephemeroptera species of North America and index to their complete nomenclature. *Trans. Am. ent. Soc.* 122:1–54.
- McCafferty, W.P. and R.D. Waltz. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. *Trans. Am. ent. Soc.* 116:769–799.
- Miller, A.M. 1987. Colonization and ecological development of new streams in Glacier Bay National Park, Alaska. *Freshwat. Biol.* 18:53–70.
- Mohihara, D.K. and W.P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). *Trans. Am. ent. Soc.* 105:139–221.
- McDunnough, J. 1924. New Canadian Ephemeridae with notes, II. *Can. Ent.* 56:128–133.
- 1928. The Ephemeroptera of Jasper Park, Alta. *Can. Ent.* 60:8–10.
- 1931. New species of North American Ephemeroptera. *Can. Ent.* 63:82–93.
- 1936. A new Canadian Baetid (Ephemeroptera). *Can. Ent.* 68:32–34.
- Moore, I.A. 1977. Species descriptions of some Plecoptera, Ephemeroptera, Trichoptera and Diptera from three areas of the Northwest Territories. *Fish. Envir. Can., Envir. Protect. Serv. Manuscript Rep.* NW-77-9. 57 pp.
- Needham, J.G., J.R. Traver, and Y.C. Hsu. 1935. *A Biology of Mayflies*. Comstock Publishing Co., New York. 759 pp.
- Oswood, M.W. 1989. Community structure of benthic invertebrates in interior Alaskan (USA) streams and rivers. *Hydrobiologia* 172:97–110.
- Pearson, W.D. and R.H. Kramer. 1972. Drift and production of two aquatic insects in a mountain stream. *Ecol. Monogr.* 42:365–385.
- Pritchard, G. and J. Zloty. 1994. Life histories of two *Ameletus* mayflies in two mountain streams: the influence of temperature, body size and parasitism. *J. N. Am. benthol. Soc.* 13:557–568.
- Provonsha, A.V. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). *Trans. Am. ent. Soc.* 116:801–884.
- Radford, D.S. and R. Hartland-Rowe. 1971. The life cycles of some stream insects (Ephemeroptera, Plecoptera) in Alberta. *Can. Ent.* 103:609–617.

- Robinson, C.T., L.M. Reed, and G.W. Minshall. 1992. Influence of flow regime on life history, production, and genetic structure of *Baetis tricaudatus* (Ephemeroptera) and *Hesperoperla pacifica* (Plecoptera). *J. N. Am. benthol. Soc.* 11:278–289.
- Scudder, G.G.E. 1975. An annotated checklist of the Ephemeroptera (Insecta) of British Columbia. *Syesis* 8:311–315.
- . 1997. Environment of the Yukon. pp. 13–57 in H.V. Danks and J.A. Downes (Eds.), *Insects of the Yukon*. Biological Survey of Canada (Terrestrial Arthropods), Ottawa.
- Soldan, T. 1986. A revision of the Caenidae with ocellar tubercles in the nymphal stage (Ephemeroptera). *Acta Univ. Carol.* 1982–1984 (Biol.): 289–362.
- Studeman, D., P. Landolt, M. Sartori, D. Hefti, and I. Tomka. 1992. Ephemeroptera (version française). *Insecta Helvetica* 9:1–175.
- Wiens, A.P., D.M. Rosenberg, and N.B. Snow. 1975. Species list of aquatic plants and animals collected from the Mackenzie and Porcupine river watersheds from 1971–1973. *Envir. Can., Fish. Mar. Serv. Tech. Rep.* 557. 39 pp.
- Zloty, J. 1996. A revision of the Nearctic *Ameletus* mayflies based on adult males, with descriptions of seven new species (Ephemeroptera: Ameletidae). *Can. Ent.* 128:293–346.