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Large, wetland-associated mayflies (Ephermeroptera) of Glacier National Park, Montana

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LARGE, WETLAND-ASSOCIATED MAYFLIES (EPHEMEROPTERA) OF GLACIER NATIONAL PARK, MONTANA

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ABSTRACT.—We describe species richness and habitat associations of mayflies (Ephemeroptera) collected during amphibian surveys of 355 water bodies in Glacier National Park (NP), Montana, in 2006–2008. We collected 9 taxa (in 7 genera) of mayflies that were identifiable to species. *Callibaetis ferrugineus hageni* was collected most frequently, followed by *Siphlonurus occidentalis, S. phyllis, Ameletus celer, A. similior, Parameletus columbiae, Ephemerella dorothea infrequens, Baetis bicaudatus,* and *Leptophlebia cupida*. *Siphlonurus phyllis* had not been reported in the western United States prior to our surveys, and *P. columbiae* is a species of concern in the region. The identifications of 4 additional taxa were uncertain due to the poor condition of specimens found at only one site (*Centroptilum* sp. and *Paraleptophlebia* sp.) or because nymphal specimens could not be confidently identified (*Cinygma* sp. and *Cinygmula* sp.). Species richness of mayflies in wetlands seems low compared to that in streams and lakes in Glacier National Park. We found the most species of mayflies in beaver ponds, where we detected some species not commonly associated with lentic water bodies. Our survey was the first extensive survey of wetland invertebrates in Glacier NP and only the second that we are aware of in western Montana.

Key words: Ephemeroptera, mayfly, wetland, Ameletus, Baetis, Callibaetis, Ephemerella, Leptophlebia, *macroinvertebrates,* Parameletus, Siphlonurus*.*

Invertebrates are the largest component of biodiversity in national parks, yet often only limited data exist for these fauna (Stohlgren and Quinn 1991, Ginsberg 1994). This lack of basic inventory work limits potential conservation efforts. Changes to precipitation, snowmelt patterns, and seasonal temperatures presumably affect the hydroperiod and characteristics of wetlands and other aquatic environments in Glacier National Park (NP), Montana, and the surrounding region (White et al. 1998, Fagre et al. 2003). Wetlands are important to local and regional biodiversity (Gibbs 2000, Amazega et al. 2002) and are threatened in many ecosystems, including protected areas (Williams 1993). Documenting current assemblages is important for measuring the effects of predicted climate changes on aquatic habitats and species in Glacier NP.

Baseline data for lentic invertebrates in Glacier NP, and western Montana in general, are sparse. Several studies have described elements of the invertebrate fauna in streams and, less frequently, in lakes of the park (Evermann 1891, Lehmkuhl 1966, Russell et al. 1967, Robson 1968, Howe 1974, Stanford 1975, Appert 1977, Hauer 1980, Perry and Sheldon 1986, Varrelman and Spencer 1991, Pepin and Hauer 2002, Newell et al. 2008). The U.S. Fish and Wildlife Service (1977, 1980, 1982) conducted the most extensive baseline surveys of stream biota; however, the reports were never published, most identifications were only to family or genus, and few specimens survive. The only study of wetland macroinvertebrates in western Montana that we are aware of focused on 21 prairie pothole wetlands and found only 2 mayfly genera, with *Callibaetis* being most common (Ludden 2000). A survey of 36 ponds in neighboring Waterton Lakes NP found 9 genera of mayflies, including *Siphlonurus, Callibaetis,* and *Leptophlebia*, with up to 6 genera per site (Anderson and Donald 1976b). Herein we report qualitative records of wetland-associated mayflies in Glacier NP.

Glacier NP is a 4082-km^2 reserve along the Canadian border, forming part of the Glacier-Waterton International Peace Park. Surface elevations range from approximately 950 m to 3190 m, and streams flow over sedimentary rocks to the Pacific, Atlantic, and Arctic oceans (Fig. 1). Much of the park is characterized by U-shaped valleys that reflect the extensive glaciation of the region during the Pleistocene

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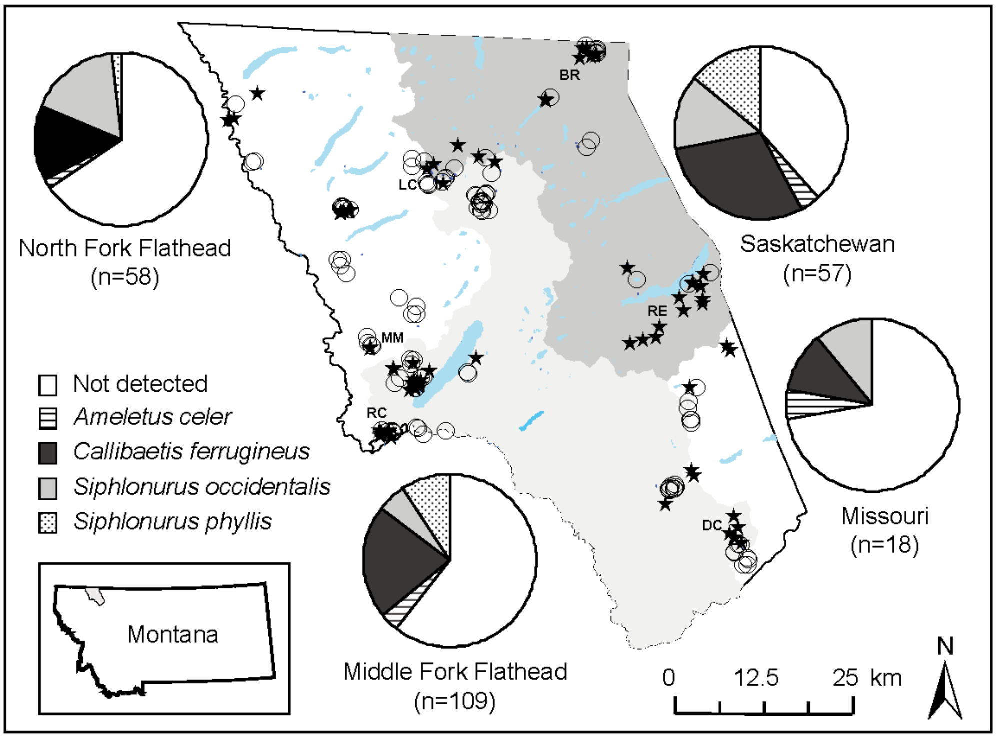

Fig. 1. Distribution of sampling effort and the proportion of water bodies where the 4 most frequently detected mayflies were found in each of the major drainages in Glacier National Park, Montana. Stars indicate where mayflies of any species were found, and hollow circles indicate where none were found. Two-letter codes on the map designate areas referenced in the manuscript (DC = Debris Creek, MM = McGee Meadow, RC = Rubideau Creek, LC = Logging Creek, RE = Red Eagle).

(Carrara 1989). West of the Continental Divide, the park is dominated by a moist Pacific maritime climate. East of the divide, the continental–polar air masses result in a colder, drier climate (Carrara 1989). Topographic and climatic variation in the park produces a variety of habitats ranging from western red cedar (*Thuja plicata*)–western hemlock (*Tsuga heterophylla*) forests typical of the Pacific Northwest to alpine tundra and grasslands.

The majority of water bodies we surveyed were wetlands <1.0 m deep and <1.0 ha. These wetlands typically fill from snowmelt in late spring and support extensive emergent vegetation. They then dry by late summer and freeze to the bottom in winter. We also surveyed valley-bottom and hillside beaver ponds, stream backwaters, ponds, high-elevation snowmelt pools, and small (usually) cirque lakes. The largest water body surveyed was 19 ha (Pitamakan Lake). Because most water bodies were palustrine or had palustrine components, we use the term 'wetlands' except when more specificity is informative.

We surveyed 355 wetlands during 2006–2008, and most were surveyed during all 3 years. Surveyed areas were either part of a long-term amphibian monitoring program in Glacier NP (Corn et al. 2005) or were in areas recently burned by wildfires where effects of fire on amphibian populations are being measured (Hossack and Corn 2007). Differences in sample size among years resulted from wetlands not filling, fire-related research, and occasional access restrictions.

Wetlands were surveyed by a team of at least 2 technicians during the approximate 6–8-week period in June to mid-August when amphibian larvae were expected to be present and free-swimming (depending on elevation and aspect). Crews searched shallow areas (≤0.5 m deep) of each site, and used a dip net (3.2 mm mesh) to capture amphibian larvae and mayflies. Most mayflies were captured incidentally, and small mayflies may have been missed because of the large mesh size of the nets. Also, we did not conduct replicate sampling within years, so our detection probabilities are unknown (e.g., MacKenzie et al. 2003). We made no inference about species that were not found at a site (i.e., we did not assume absence). Mayflies were collected in 40-mL specimen containers and fixed in ~80% ethyl alcohol. A cotton ball was added to each container to minimize damage to the specimens during transport from the field. Specimens were identified at the University of Montana, Flathead Lake Biological Station. Coordinates for each wetland were recorded with a handheld GPS unit.

We collected 13 taxa of mayflies from 355 wetlands in 2006–2008. The identities of 4 species were uncertain due to the poor condition of specimens found at only one site (*Centroptilum* sp. and *Paraleptophlebia* sp.) or because nymphal specimens could not be confidently identified (*Cinygma* sp. and *Cinygmula* sp.). We found only one species at most sites (range 1–4). In comparison, local streams and lakes may host ≥16 and ≥12 species, respectively (Stanford 1975, USFWS 1977, 1980, 1982, Perry and Sheldon 1986, Varrelman and Spencer 1991). We suspect that the low species richness we detected is attributable to small nymphs passing through the large mesh size of our nets and to unfavorable habitat. Additional surveys focused specifically on invertebrates may reveal other lentic species known from the area, including Baetidae, Caenidae, and Leptohyphidae, as well as greater richness within sites. For example, local lakes contain species of Caenidae and Heptageniidae that we did not find in wetlands (Perry and Sheldon 1986, Varrelman and Spencer 1991). These taxa may be confined to larger lakes that we did not sample.

We report coordinates for all wetlands where we collected mayflies that we could identify to species (Appendix).

FAMILY ACCOUNTS

Ameletidae

We collected 2 species of *Ameletus: A. celer* McDunnough, 1934 and *A. similior* McDunnough, 1928. Both have been collected previously in western Montana, where *A. celer* is common in high-elevation lakes (J. Zloty, private contractor, personal communication). We found *A. celer* at only 8 sites, but it was present throughout the park in a variety of habitats (Fig. 1). The shallow sites occupied by *A. celer* were always associated with streams.

Ameletus similior was collected only from the same small, palustrine wetland along Debris Creek (Ole Creek drainage) in 2006 and 2007. We did not collect this species elsewhere in the Ole Creek drainage even though there were several similar sites nearby. *Ameletus similior* is present in high-elevation lakes in the region (Zloty personal communication) but is rare in Glacier NP (R. Newell unpublished data).

Baetidae

A single mature nymph of *Baetis bicaudatus* Dodds 1923 was collected in 2008 at a site that is connected to a stream. This species is a common stream inhabitant of western Montana (USFWS 1977, 1980, 1982, McCafferty and Newell 2007).

We found *Callibaetis ferrugineus hageni* Eaton 1885 more often than any other species (Fig. 1). This species is found in lakes and ponds throughout the western U.S. and is one of the most common mayflies in the Rocky Mountains (Check 1982, McCafferty et al. 1997). We found it most frequently at sites with soft sediments and extensive emergent vegetation, including several beaver ponds. Surprisingly, we did not find it in lakes; however, our sampling efficiency was likely lower in lakes than it was in shallow wetlands.

We were surprised that *C. ferrugineus* was common in seasonal wetlands because this species is typically multivoltine except at high elevations (e.g., ≥3000 m elevation; Caudill 2002) and produces eggs that contain fully developed nymphs (ovoviviparity); therefore, it does not have a free-egg stage that can survive dessication (Edmunds 1945, Gibbs 1979). Ovoviviparity suggests that *C. ferrugineus* may be adapted to temporary habitats, however, and many seasonal wetlands contained this species during all 3 years of sampling. We suspect that seasonal wetlands are colonized each spring by migrants from permanent water bodies, where nymphs can overwinter. Whether seasonal habitats are demographic sinks would depend on development times and interannual variation in hydroperiod.

We collected one *Centroptilum* nymph from a shallow marsh southwest of McGee Meadow. Its poor condition prevented species identification. *Centroptilum conturbatum* McDunnough, 1929—and less commonly *C. bifurcatum* McDunnough, 1924—have been collected from several lakes in western Montana (McCafferty and Newell 2007).

Ephemerellidae

Ephemerella dorothea infrequens (McDunnough) 1924 was collected at the same beaver pond in the Rubideau Creek catchment in 2006 and 2007. Along with *E. excrucians* Walsh, 1862, it is a common lotic species in western Montana (USFWS 1977, 1980, 1982; R. Newell unpublished data).

Heptageniidae

An unidentified *Cinygma* sp. was collected from 2 lentic sites that were associated with streams. This *Cinygma* sp. is a common stream inhabitant in the park (USFWS 1977, 1980, 1982). Adults of *Cinygma dimicki* McDunnough, 1934 and *C. integrum* Eaton, 1885 have been collected in local streams (McCafferty and Newell 2007).

A single *Cinygmula* sp. individual was collected from a small cirque lake, where it probably came from an associated stream. Seven species of *Cinygmula* have been documented in streams and lakes of the park (McCafferty and Newell 2007). Nymphal *Cinygma* and *Cinygmula* cannot be identified to species.

Leptophlebiidae

We found *Paraleptophlebia* sp. in one beaver pond in the Rubideau Creek drainage in 2007. The poor condition of the nymph prevented species identification. Several species of *Paraleptophlebia* are present in streams and lakes of western Montana (McCafferty and Newell 2007).

One nymph of *Leptophlebia cupida* (Say) 1823 was captured in 2008 from an old beaver pond near McGee Meadow. This species is occasionally found in local lakes (R. Newell unpublished data).

Siphlonuridae

Parameletus columbiae McDunnough, 1938, a species of concern in several western states and British Columbia (NatureServe 2008), was found only in 2008, when we collected it from 7 wetlands. Only one of the collection sites for this species was surveyed during 2006–2007, but the survey date was likely too late to detect the nymphs. This species hatches during snowmelt from dormant eggs laid the previous spring, and it has a brief nymphal period (Edmunds 1957). Five of the *P. columbiae* collection sites were isolated, temporary marshes near the McGee Meadow area, where we collected nymphs between 11 June and 15 June. The remaining sites were on the east side of park, where mature nymphs were captured on 7 July and 26 July. *Parameletus columbiae* has been collected previously from 2 locations in Glacier NP: an adult collected near Gunsight Pass on 19 July 1997 and a nymph collected from floodplain ponds along the Middle Fork of the Flathead River on 13 June 2002 (McCafferty and Newell 2007, R. Newell unpublished data).

Siphlonurus occidentalis (Eaton), 1885 was the second-most frequently collected species and is widespread in the park (Fig. 1). This species was most commonly found in sites with soft substrates and is common throughout western Montana (R. Newell unpublished data). As with *A. celer,* we found *S. occidentalis* across the entire elevation range we sampled, including in several small pools near the Continental Divide in upper Logging Creek.

Siphlonurus phyllis McDunnough, 1923 was first collected in Glacier NP in 2006 during wetland surveys for amphibians, and that record was the first for *S. phyllis* from the western United States (Berner 1983; see McCafferty and Newell 2007). Described from Alberta, this species is common across much of Canada (McDunnough 1923, Harper and Harper 1981, 1997, McCafferty et al. 1998, Randolph 2002) but has not been reported from southern Alberta since its description (Anderson et al. 1972, Anderson et al. 1976, Anderson and Donald 1976). The distribution of *S. phyllis* in Glacier NP is extensive, although we did not find this species in the Missouri River drainage (Fig. 1). *Siphlonurus phyllis* seemed less common than *S. occidentalis* and was more strongly associated with shallow emergent wetlands than was *S. occidentalis.* The 2 species were found co-occurring in only 2 beaver ponds on Red Eagle Creek, but the known distribution of *S. phyllis* and *S. occidentalis* within the park (including co-occurrence) will likely expand with further sampling because entire collections of *Siphlonurus* sp. nymphs from several wetlands were too immature to identify.

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APPENDIX. Coordinates (GRS80) of wetlands in Glacier National Park where mayflies were collected during 2006–2008. Only specimens identifiable to species are listed.

Latitude	Longitude	Species collected
48.920922	114.326468	*Siphlonurus phyllis*
48.887968	114.352347	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.919403	114.329822	*Callibaetis ferrugineus hageni*
48.889938	114.350827	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.780687	114.111810	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.778752	114.114168	*Ameletus celer, Callibaetis ferrugineus hageni, Ephemerella dorothea infrequens, Siphlonurus occidentalis*
48.779874	114.116607	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.777404	114.130381	*Callibaetis ferrugineus hageni*
48.777577	114.130964	*Callibaetis ferrugineus hageni*
48.779454	114.123456	*Siphlonurus occidentalis*
48.777530	114.129368	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.813786	113.967798	*Siphlonurus occidentalis*
48.820379	113.969264	*Siphlonurus occidentalis*
48.814965	113.972309	*Siphlonurus occidentalis*
48.815125	113.971365	*Siphlonurus occidentalis*
48.640270	114.117615	*Callibaetis ferrugineus hageni*
48.637757	114.102064	*Callibaetis ferrugineus hageni*
48.621905	114.021789	*Parameletus columbiae*
48.621372	114.025313	*Parameletus columbiae*
48.614437	114.055852	*Parameletus columbiae*
48.618542	114.064935	*Parameletus columbiae*
48.617650	114.062275	*Parameletus columbiae*
48.614021	114.049503	*Leptophlebia cupida*
48.569583	113.977546	*Callibaetis ferrugineus hageni*
48.566443	113.983096	*Callibaetis ferrugineus hageni*
48.557530	113.984700	*Callibaetis ferrugineus hageni*
48.495362	114.016420	*Callibaetis ferrugineus hageni*
48.583378	114.018608	*Callibaetis ferrugineus hageni*
48.582512	114.016658	*Callibaetis ferrugineus hageni*
48.504869	114.021737	*Callibaetis ferrugineus hageni*
48.503642	114.021502	*Callibaetis ferrugineus hageni*
48.506263	114.029295	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.505718	114.029114	*Ameletus celer, Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.504726	114.029231	*Ameletus celer, Callibaetis ferrugineus hageni*
48.503427	114.038889	*Callibaetis ferrugineus hageni*
48.501845	114.036777	*Siphlonurus phyllis*
48.497935	114.037653	*Callibaetis ferrugineus hageni, Siphlonurus phyllis*
48.497021	114.039561	*Callibaetis ferrugineus hageni, Siphlonurus phyllis*
48.500085	114.035981	*Callibaetis ferrugineus hageni*
48.499458	114.034833	*Siphlonurus phyllis*
48.501638	114.021748	*Callibaetis ferrugineus hageni*
48.501590	114.020825	*Callibaetis ferrugineus hageni*
48.560686	113.974340	*Siphlonurus phyllis*
48.564293	113.969535	*Siphlonurus phyllis*
48.562819	113.968744	*Siphlonurus phyllis*
48.558047	113.973060	*Siphlonurus phyllis*
48.569840	113.964844	*Siphlonurus phyllis*
48.563460	113.966572	*Callibaetis ferrugineus hageni*
48.581374	113.948419	*Callibaetis ferrugineus hageni*
48.569418	113.970704	*Siphlonurus phyllis*
48.600865	113.860683	*Callibaetis ferrugineus hageni*
48.565825	113.972553	*Callibaetis ferrugineus hageni*
48.824435	113.933216	*Callibaetis ferrugineus hageni*
48.819130	113.936585	*Siphlonurus occidentalis*
48.424223	113.491831	*Siphlonurus occidentalis*
48.444678	113.484177	*Callibaetis ferrugineus hageni*
48.442848	113.462585	*Ameletus celer*
48.440145	113.485781	*Ameletus celer, Callibaetis ferrugineus hageni*
48.378145	113.344659	*Ameletus similior*
48.372995	113.347934	*Callibaetis ferrugineus hageni*
48.374556	113.353003	*Callibaetis ferrugineus hageni*

Appendix. Continued.

Latitude	Longitude	Species collected
48.383225	113.355834	*Callibaetis ferrugineus hageni*
48.320305	113.381143	*Callibaetis ferrugineus hageni*
48.384774	113.359282	*Callibaetis ferrugineus hageni*
48.390406	113.367648	*Callibaetis ferrugineus hageni*
48.411084	113.361892	*Ameletus celer, Siphlonurus occidentalis*
48.348521	113.333351	*Siphlonurus occidentalis*
48.461327	113.438655	*Ameletus celer*
48.543575	113.455966	*Ameletus celer*
48.570586	113.449668	*Ameletus celer, Siphlonurus occidentalis*
48.571390	113.449504	*Parameletus columbiae*
48.679798	113.432733	*Callibaetis ferrugineus hageni*
48.703246	113.453926	*Callibaetis ferrugineus hageni*
48.704968	113.453330	*Siphlonurus phyllis*
48.685846	113.482838	*Callibaetis ferrugineus hageni*
48.697723	113.444959	*Callibaetis ferrugineus hageni, Siphlonurus phyllis*
48.633605	113.531598	*Siphlonurus occidentalis*
48.622081	113.547022	*Siphlonurus occidentalis, Siphlonurus phyllis*
48.616140	113.566997	*Siphlonurus occidentalis, Siphlonurus phyllis*
48.632306	113.521502	*Callibaetis ferrugineus hageni*
48.717124	113.433798	*Callibaetis ferrugineus hageni*
48.713791	113.438260	*Callibaetis ferrugineus hageni, Siphlonurus phyllis*
48.728002	113.554313	*Ameletus celer*
48.986241	113.661493	*Callibaetis ferrugineus hageni*
48.988183	113.655308	*Callibaetis ferrugineus hageni*
48.988022	113.654479	*Siphlonurus phyllis*
48.997287	113.670149	*Callibaetis ferrugineus hageni*
48.996198	113.678296	*Callibaetis ferrugineus hageni, Siphlonurus phyllis*
48.983833	113.684222	*Callibaetis ferrugineus hageni, Siphlonurus phyllis, Siphlonurus occidentalis*
48.984080	113.684796	*Callibaetis ferrugineus hageni*
48.993168	113.653727	*Callibaetis ferrugineus hageni*
48.929850	113.745987	*Callibaetis ferrugineus hageni, Siphlonurus occidentalis*
48.928673	113.745158	*Siphlonurus occidentalis*
48.836743	113.969032	*Ameletus celer*
48.839082	113.965231	*Ameletus celer, Siphlonurus occidentalis*
48.860525	113.920448	*Siphlonurus occidentalis*
48.860725	113.873154	*Siphlonurus occidentalis*
48.627384	113.384704	*Callibaetis ferrugineus hageni*
48.624570	113.382848	*Callibaetis ferrugineus hageni*
48.655528	113.659932	*Parameletus columbiae*