Unexplored Diversity:
Macroinvertebrates in Coastal British Columbia Headwater Streams

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ABSTRACT

At the very tips of most drainage networks are small stream channels, many of which have no flow at times during the summer. These small, zero-order streams contribute a significant portion of cumulative stream length in a watershed, but are largely unexplored and receive little protection under current legislation. We studied the aquatic macroinvertebrate assemblage of 7 small coastal streams with a range of permanence of flow. Three streams have no detectable surface flow for periods in summer (i.e., intermittent flow). We hypothesize that the invertebrate assemblage in these zero-order streams does not completely overlap that of larger streams. Stream sites were sampled using a combination of emergence traps emptied every 14 days throughout the year. In even the smallest streams (<0.5 m bankfull width) with intermittent flow, true aquatic insects with 1-year life cycles were found emerging, even in periods when no flow was perceptible. Species richness in intermittent and continuous streams was approximately equal, while intermittent streams appeared to produce as much as twice the number of adult stoneflies as continuous streams. This study shows that even intermittent streams harbour a true aquatic fauna and, potentially, species for which little is known, and indicates that these unique habitats make an important contribution to their ecosystems.

Key words: aquatic invertebrate, coastal watershed, intermittent stream, Plecoptera, riparian.

The small streams at the tips of catchments in watersheds are variable in their periodicity of flow: some flow continuously throughout the year, and others only flow during precipitation events or when groundwater levels are high. At certain times in the year a portion of these small, zero-order streams have no perceptible surface flow; that is, they have intermittent flow. While zero-order streams constitute a significant proportion of stream length in a watershed (Sidle et al. in press), these systems have been largely ignored by scientific studies of aquatic fauna. Since the riparian zones in which these small streams exist contain valuable resources and habitat (Davies and Nelson 1994), their management and protection is related to their value as buffer strips, stream bank stabilizers, and fish and wildlife habitat (Mahoney and Erman 1984).

Despite the importance of riparian habitat to ecosystem function, and the concentration of biodiversity in aquatic environs, only 1 other study in the Pacific Northwest (Dieterich and Anderson 1995) has attempted to explore the benthic macroinvertebrate fauna of these unique headwater stream habitats. Threats to benthic invertebrates are important, as these organisms are key in the trophic chain of food webs in stream ecology and they support other organisms, such as salmonids, that are of cultural and economic concern in British Columbia (B.C. MOF and B.C. MELP 1995). Unfortunately, despite their unexplored status, these unique streams are afforded little, if any, protection under current legislation .

We know very little about biodiversity in headwater streams. As part of a larger, integrated project to test current riparian guidelines, we focused on aquatic insects in zero-order streams. We hypothesized that the invertebrate assemblage in these zero-order intermittent streams does not completely overlap, or is distinct from, that of larger and continuously flowing streams.

STUDY AREA

This study was located in the University of British Columbia's Malcolm Knapp Research Forest. This research forest is located in Maple Ridge, B.C., approximately 60 km east of Vancouver, in the rainy, temperate Fraser Valley foothills (elevation 140–450 m). The sites are located in the Coastal Western Hemlock biogeoclimatic zone, have glacial, primarily

Table 1. Stream site parameters, University of British Columbia Malcolm Knapp Research Forest.

	Site B	Site F	Site I	Site G	Site H	East Cr.	Mike Cr.
Watershed area (ha)	13.5	12	12.6	68.9	40.8	44	25
Gradient (% slope)	14.25	12	20	3	3	14	12
Periodicity of flow[a]	I	I	I	C	C	C	C

[a] I = intermittent; C = continuous.

acidic soils, and are underlain by igneous rocks (Feller 1979). The 7 stream sites are located at the southwestern corner of the research forest, which experienced a large-scale fire in 1931 and abuts Golden Ears Provincial Park. All streams are designated S4, S5, or S6 under the Forest Practices Code of British Columbia (B.C. MOF and B.C. MELP 1995). They have a range of permanence of flow, with 3 having no detectable surface flow for periods in summer (i.e., intermittent flow). See Table 1 for experimental stream parameters.

METHODS

Stream sites were sampled using a combination of 2 emergence traps per site sampled biweekly throughout the year, and spring/fall Surber sampling. Aquatic macroinvertebrates were field preserved in propylene glycol (adults) and formalin (nymphs). Individuals were sorted and identified to species using Merritt and Cummings (1996) and other keys, and preserved in ethyl alcohol. For this paper, only emergent adult stoneflies will be considered as an index of the broader study.

RESULTS

In even the smallest streams (<0.5 m bankfull width) with intermittent flow, true aquatic insects with 1-year life cycles were found emerging, even in periods when no flow was perceptible. Some examples of these species include *Soyedina producta*, *Moselia infuscata*, *Despaxia augusta*, and *Zapada cinctipes*. All species found in intermittent streams were also present in continuous channels but not vice versa, indicating that the headwater fauna is mostly a subset of downstream fauna in these zero-order channels (Table 2). Plecopteran adults emerging have approximately the same species richness (Fig. 1), and higher densities (Fig. 2) in intermittent streams than in continuously flowing sites. In intermittent sites the number of individuals emerging approached twice that of continuous streams for the 2-week monitoring periods. *D. augusta* (Leuctridae) was often the largest contributor to intermittent stream biomass, where it reached its highest densities in all tabulated months.

Table 2. Stoneflies (Plecoptera) collected as adults from intermittent and continuously-flowing streams in the University of British Columbia Malcolm Knapp Research Forest.

Intermittent flow	Continuous flow
Alloperla perlosa	*Alloperla perlosa*
	Bolshecapnia sp.
	Chernokrilus sp.
Despaxia augusta	*Despaxia augusta*
Malenka spp.	*Malenka* spp.
Moselia infuscata	*Moselia infuscata*
	Nemoura sp.
Ostracerca fosteri	*Ostracerca foesteri*
	Osborus sp.
	Paraleuctra vershina
Pteronarcys californica	*Pteronarcys californica*
Soyedina producta	*Soyedina producta*
	Sweltsa sp.
Zapada cinctipes	*Zapada cinctipes*
Zapada oregonensis	*Zapada oregonensis*
	Visoka cataractae

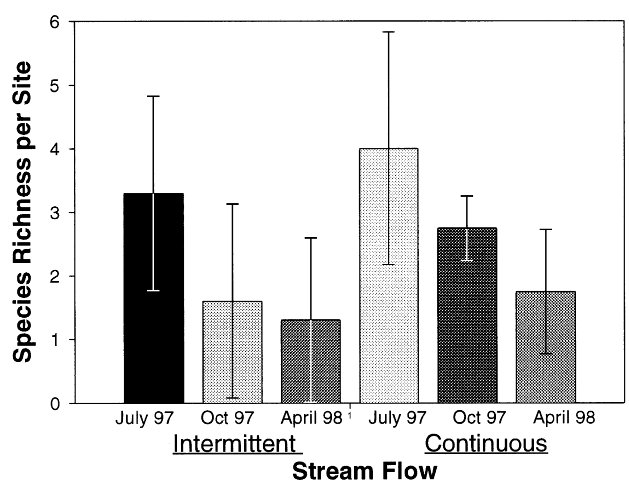

Figure 1. Stonefly (Plecoptera) species richness in intermittent and continuously-flowing streams at the University of British Columbia Malcolm Knapp Research Forest. Error bars indicate standard error for 3 intermittent and 4 continuously-flowing streams per sampling date.

DISCUSSION

Invertebrates are microhabitat-specific, and ongoing physical, biological, and geochemical conditions of the stream determine their abilities to persist (Sweeney 1984). Changes in microhabitat are reflected in changes in species composition and richness (Davies and Nelson 1994). Rather than being biologically barren, intermittent channels harbour a true aquatic fauna, emerging even in periods of no discernible flow, and rival the species richness of more stable continuous sites. *D. augusta*, with its 2-year life cycle, is able to complete its development in these periodically "dry" channels, and reaches its highest densities in intermittent streams. This suggests that suitable refugia exist for this species and others in the wetted sediments of these habitats, despite the periodic disappearance of detectable surface flow.

All species found in intermittent streams were also located in continuous channels, but not vice versa. This suggests that intermittent site fauna are a subset of continuous site fauna in these zero-order streams. Species missing from the intermittent assemblage appeared to be large-bodied, long-lived stoneflies (e.g., *Pteronarcys californica*) that required more oxygenated, faster flows than were available in the intermittent streams.

It is unknown at this point in our study whether the intermittent fauna is a unique subset of continuous and/or downstream fauna (higher order streams) and can be predicted from the periodicity of water flow by nested subset analysis. The relationship of the continuous and intermittent fauna to that of larger downstream reaches, (Richardson 1992), seems to indicate that downstream sites may act as sources for some species that may only survive in high water-flow conditions.

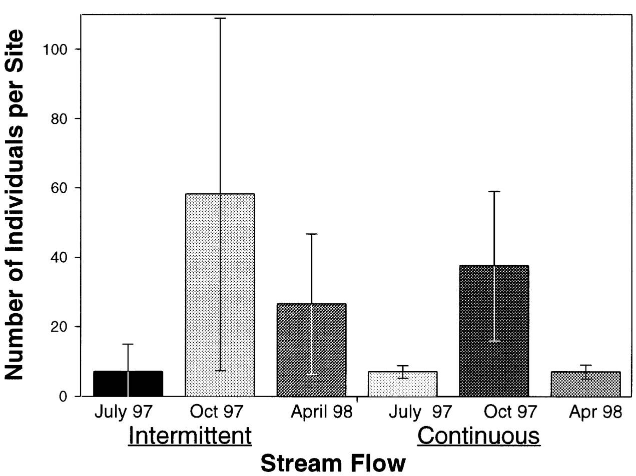

Figure 2. Stonefly (Plecoptera) adult density in intermittent and continuously-flowing streams at the University of British Columbia Malcolm Knapp Research Forest. Error bars indicate standard error for 3 intermittent and 4 continuously-flowing streams per sampling date.

MANAGEMENT IMPLICATIONS

Riparian zones play critical roles in maintenance of biodiversity (Clayoquot Sound Scientific Panel 1995), and in maintenance of aquatic biota (Mahoney and Erman 1984). Anthropogenic change in riparian zones, such as forestry, is of particular concern to benthic invertebrates, which are dependent on riparian vegetation for some stage of their life cycle and for maintenance of stream conditions for which they have evolved (Erman 1984, Mahoney and Erman 1984). Because all of these factors have the potential to critically impact the zero-order streams, it seems that further exploration is warranted, especially concerning the consequences of riparian management. These unique sites are not currently afforded protection, and consequently the species that exploit these zero-order streams may be detrimentally affected and their important contribution to these ecosystem's function lost.

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