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SHORT COMMUNICATION

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A simple method for sampling invertebrate drift in large rivers and boulder-bed streams

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Abstract

Sampling invertebrate drift in high-gradient boulder-bed channels or large turbulent rivers is challenging, because the traditional approach of driving stakes into the stream bed to secure drift nets may not work. We describe a simple method using a split wading rod to collect drift samples from the wadeable river margin or bank as an alternative method for rapid assessment of invertebrate drift when boat access is not possible. Pilot sampling in a large river shows that near-shore drift samples collected with this approach are broadly similar to samples collected from the centre of the channel using more conventional methods, although our results suggest that depth and velocity effects may cause drift concentrations to be elevated closer to the bank.

KEYWORDS

drift net, drift sampling, invertebrate drift, stream

1 | INTRODUCTION

Suspended invertebrates in streams and rivers (invertebrate drift) are the primary food source for drift-feeding fishes like salmonids and many cyprinids (Grossman, 2014; Naman, Rosenfeld, & Richardson, 2016). Quantifying the abundance of drift is ecologically important (Rosenfeld, Bouwes, Wall, & Naman, 2014; Weber, Bouwes, & Jordan, 2017) and analogous to measuring zooplankton abundance for planktivores in lakes. However, spatial variation in drift and ecological drivers of drift abundance are generally more poorly documented than variation in zooplankton abundance in lakes and ponds, partly because of the logistic challenges involved in sampling drift in many riverine habitats.

Collecting drift can be particularly challenging in steep gradient high-energy systems that are too large to be wadeable. As with zooplankton collection in lakes, a boat may allow drift sampling in larger rivers (Baxter, Kennedy, Miller, Muehlbauer, & Smock, 2017; Kennedy et al., 2014); however, boats may be impractical or unsafe in steep turbulent rivers or in remote areas where poor access precludes launching a boat. In this note, we describe a simple device for sampling drift in large rivers or steep high-energy systems that allows rapid sample collection with minimal investment in equipment and logistics. The method is based on sampling drift in the wadeable channel adjacent to the river bank; we also present data showing that drift collected near shore is similar to drift collected from the deeper centre channel that may have limited accessibility.

2 | DRIFT SAMPLER

Drift nets are analogous to zooplankton nets that are towed through the water column of lakes, except that drift nets are usually fixed while the water column flows through the net. Drift nets in small streams are typically staked with metal rods driven into the stream bed (Elliott, 1970; Field-Dodgson, 1985), attached to a buoy or rope anchored to the stream bottom in deeper rivers (Hayes, Goodwin, Shearer, Hay, & Kelly, 2016), or lowered into a river from a winch mounted on the bow of a power boat (Baxter et al., 2017). Staking drift nets to the substrate with metal rods is the most practical deployment method in wadeable streams with gravel- to cobble-sized substrate (Baxter et al., 2017). However, in boulder-bed channels, it becomes difficult to drive metal rods into boulder interstices, particularly if rods need to be vertical or evenly spaced. A simple alternative in boulder-bed channels is to attach the drift net to a metal rod that is held vertically in the water column by a biologist who securely seats the lower tip of the rod on the stream bed while supporting the upper end (Figure 1). A straight piece of ¾″ steel re-enforcing rod (rebar) can be used for this purpose (Figure 1a,b), although care must be taken that the rod does not contaminate the drift sample by disturbing the benthos upstream of the net, particularly if the water is shallow and the net is deployed close to the stream bed (Figure 1). An alternative is to create a split rod that allows the net to be deployed directly above the toe of the rod rather than downstream of it, alleviating any concerns that benthic invertebrates may be dislodged into the net (Figure 1c,d).

The split rod is easily constructed of galvanized ½″ (18-mm outside diameter) electrical conduit pipe at a cost of well under $100 (Figure 2). Four carabiners are attached to the collar of the drift net and clipped to the split rod, allowing easy depth adjustment by sliding the carabiners and attached net up and down the rod. The split rod could also be fitted with a simple rope and pulley system to manually raise and lower the net for depth integrated sampling. Aperture size of drift nets vary depending on study objectives; larger nets ensure a more spatially representative sample collected in a short time period

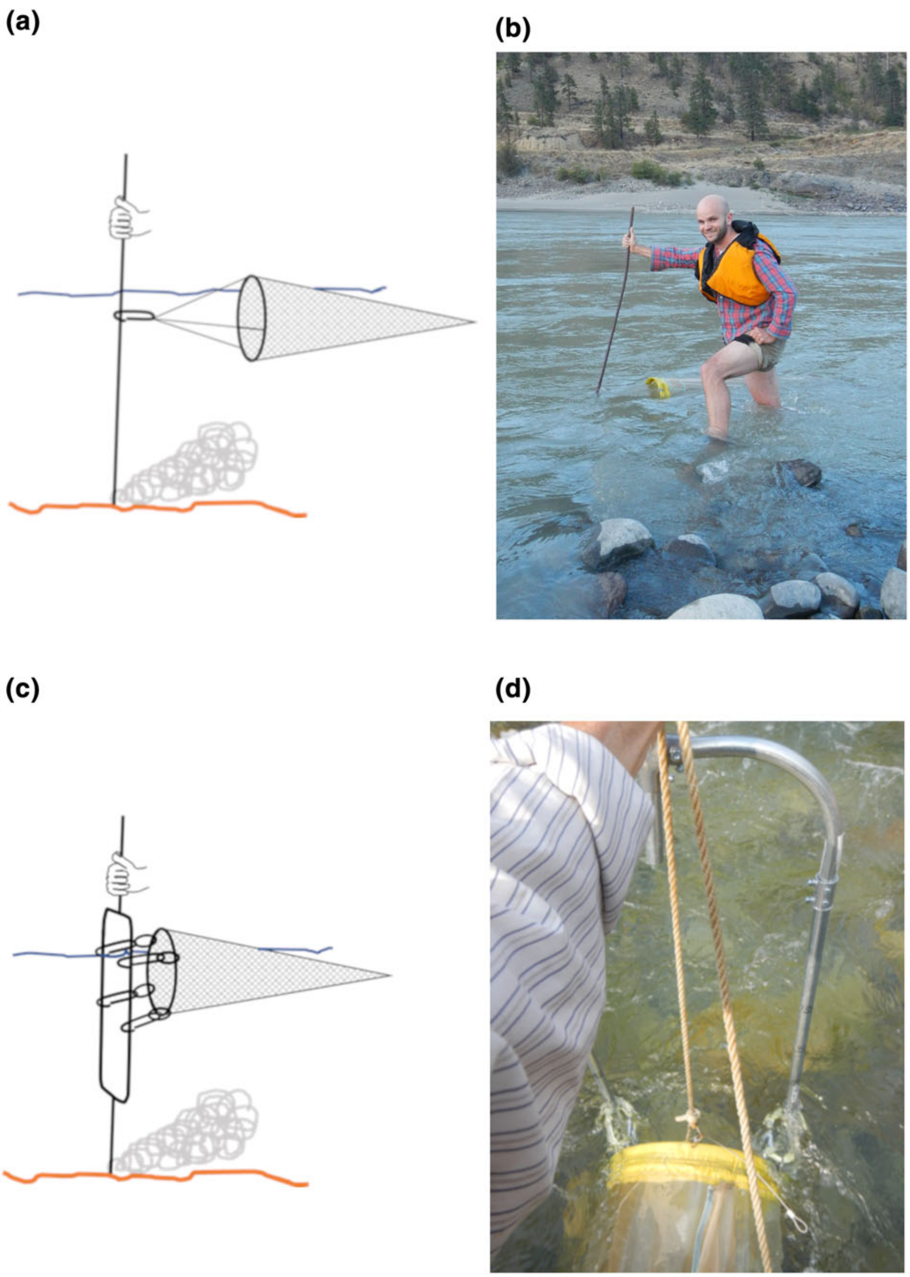

FIGURE 1 The single-rod approach for sampling drift (a), with deployment in the Fraser River near Lytton (b). The split-rod drift sampler (c) and its deployment in Grant Creek near Mt. Robson, Fraser River headwaters (d). Note that the net in (c) is more directly above the toe of the rod, so any benthos dislodged by the base of the rod (illustrated by the grey plume) will not enter the net [Colour figure can be viewed at wileyonlinelibrary.com]

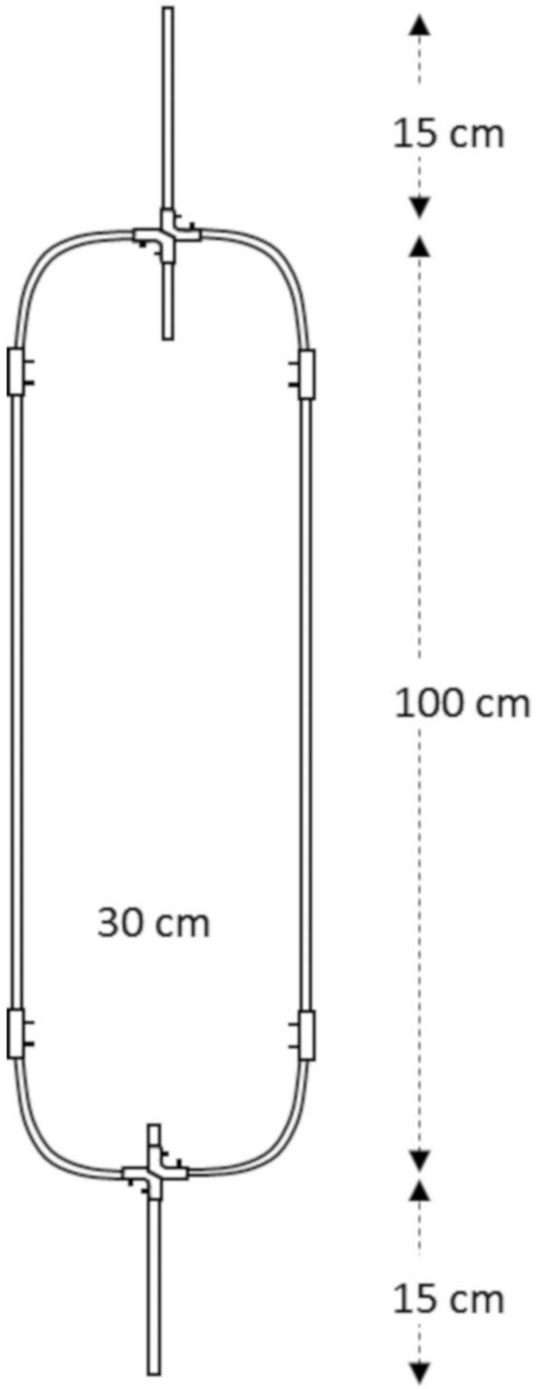

FIGURE 2 Design of the split-rod support for drift sampling. All fittings are made or 1/2″ (18 mm outside diameter) electrical conduit pipe

(Baxter et al., 2017), whereas smaller nets allow assessment of finer-scale spatial variation in drift concentration (Cienciala & Hassan, 2018). Because our intent was to sample high-velocity habitats with the potential to quickly clog the mesh of the net (Baxter et al., 2017; Muehlbauer, Kennedy, Copp, & Sabol, 2017), we used a large 30-cm diameter collar ring with a 1.8-m long bag that widened at the downstream end to increase the net surface area and reduce backpressure at the mouth of the net. We used a 250-μm mesh to capture invertebrates in a lower size range that may contribute substantially to prey availability for smaller fish (Keeley & Grant, 1997).

Sampling drift from river margins rather than the deeper centre channel implicitly assumes that drift in the wadeable margin is representative of drift in the thalweg; that is, it assumes that drift is either well mixed laterally or that drift entry and transport rates are similar across the channel, resulting in similar drift concentrations. To test this assumption, we collected drift samples from the wadeable margins and thalweg of the Fraser River on September 10, 2015 at Aggasiz, British Columbia, where the channel is approximately 300 m wide with a recorded discharge of ~1,730 m^3 on the day of sampling. Four samples were collected from near the river thalweg by lowering the drift net with a winch from the walkway of the Agassiz bridge; thalweg samples were laterally separated by approximately 10 m. Three samples were collected from near the left bank of the river, and four samples were collected from the right bank using the split rod as described above with the same net. The water depth at the river margin samples ranged from 0.55 to 0.85 m (Table S1), velocities in the mouth of the net ranged from 0.34 to 1.11 m/s, and samples were collected at a distance ranging from 3 to 10 m from the wetted river edge, with the depth of collection and distance from shore limited by safety concerns. Depth at the thalweg where the four samples were collected from the bridge was 1.7 m, and velocities in the mouth of the drift net ranged from 1.25 to 1.51 $m{\cdot}s^{-1}$ (measured using a General Oceanics model 2030R flowmeter). Sample collection began at 12:49 PM for the thalweg samples, followed by right bank samples and then left bank samples, and ended at 5:42 PM approximately 1 hour before sunset. Alternating thalweg and marginal samples would have been ideal to control for time effects, but logistics precluded this sampling design. Drift nets were set with the top 5.5 cm above the water surface to ensure capture of surface drifting terrestrial insects, resulting in an approximately 24.5-cm wide surface sampling width for terrestrial invertebrates and 0.060 m^2 of cross-sectional area below the water surface, equivalent to a square mouth net 24.5 cm wide. In large turbulent rivers, short net sets are usually necessary to prevent drift nets from clogging with fine particulates (Baxter et al., 2017); consequently, drift net sets were less than 10 min (mean 6.2 min, range 4.6–10 min) and volume of water sampled ranged from 8.0 to 26.8 m^3 (mean of 17.4 m^3).

Samples were preserved in 70% ethanol, and invertebrates were sorted from detritus in the lab at 10–16× magnification under a dissecting microscope, identified to the lowest taxonomic unit (generally family or genus or subfamily in the case of chironomids), and length was then measured using a digitizing pad and a drawing tube (Roff & Hopcroft, 1986). Invertebrates were classified as terrestrial or aquatic in origin, and biomass of individuals was estimated using published length–weight regressions for aquatic (Benke, Huryn, Smock, & >Wallace, 1999; Meyer, 1989; Sabo, Bastow, & Power, 2002) and terrestrial invertebrates (Edwards, 1966; Gowing & Recher, 1984; Sample, Cooper, Greer, & Whitmore, 1993). The volume of water filtered in each drift set was calculated as the product of velocity in the mouth of the net, duration of each set, and cross-sectional area of the drift net.

Analysis of variance was used to compare drift numbers and biomass per cubic metre collected at the thalweg with the left and right river banks for terrestrial and aquatic invertebrates separately. The left and right bank samples were also pooled into a single treatment (n = 7) to increase statistical power and compared with thalweg samples using a t test (SAS Institute, 1999). Aquatic drift concentration (number of individuals per cubic metre) was regressed against velocity and depth at the location of sampling to determine whether these covariates influenced drift concentration. Finally, to determine whether community structure differed between near-bank and thalweg samples, we visually assessed nonmetric multidimensional scaling plots (nMDS) based on Bray–Curtis similarity matrices constructed using the vegan package (Oksanen et al., 2017) in R version 3.3.2 (R Core Team, 2013).

3 | RESULTS

There was no significant difference in the concentration of total aquatic invertebrate drift (individuals per cubic metre) among the left bank (n = 3), centre (n = 4), and right bank (n = 4) samples (ANOVA, $F_{2,8}$ = 3.24, p > 0.9). However, when samples from the left and right bank were pooled (n = 7), concentration of total aquatic invertebrates was significantly higher near the stream banks than in the centre channel (Figure 3; t_9 = 2.70, p < 0.025). In contrast, concentrations of terrestrial invertebrates were more variable and did not differ among collection locations in terms of either numbers (t_9 = 0.48, p < 0.64) or biomass per cubic metre (t_9 = −1.2, p < 0.27). The greater variation in terrestrial drift concentration was particularly noticeable for winged ants, which increased throughout the day (Figure 3), reflecting a synchronous adult hatch. Aquatic drift concentration decreased significantly with velocity ($F_{1,9}$ = 20.3, R^2 = 0.69, p < 0.002; Figure 3) and increased at shallower sampling depths ($F_{1,9}$ = 10.5, R^2 = 0.54, p < 0.01). NMDS ordination showed broad overlap among samples collected from the river thalweg and banks, indicating similar community structures (Figure 4).

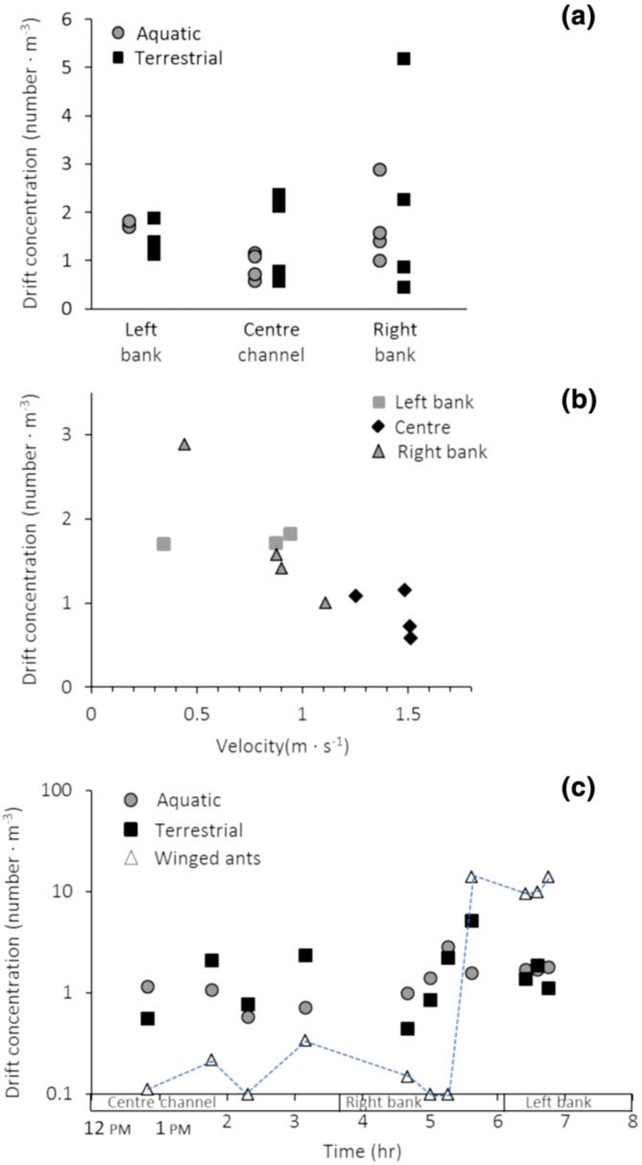

FIGURE 3 Aquatic and terrestrial drift concentrations at left bank, centre channel, and right bank sampling locations (a). Concentration of aquatic drift as a function of water velocity at the point of sampling (b). Temporal trends in concentration of aquatic drift, terrestrial drift (excluding winged ants), and winged ants (broken line; c) [Colour figure can be viewed at wileyonlinelibrary.com]

4 | DISCUSSION

Conventional approaches for sampling drift (i.e., staking drift nets with metal rods or sampling drift from boats) perform well in shallow habitats in wadeable streams or in deeper river channels. However, these methods do not work well in steeper channels that are too turbulent for safe boat operation or in wadeable channels where boulder substrate makes it difficult to drive rods into the stream bed. The method outlined above provides a simple approach for effectively sampling these challenging habitats with limited logistic investment.

Although community structure broadly overlapped between the thalweg and near-bank drift samples, drift concentrations tended to be lower at the thalweg, where both velocities and depths were higher. This pattern was surprising, because we expected that higher velocity and turbulence at the thalweg might elevate drift concentrations. Although our very small sample size necessitates caution in interpreting this pattern, it is consistent with either (a) higher drift concentrations closer to the stream bed (i.e., in the shallower near-shore samples; e.g., Sagar & Glova, 1992), or (b) accumulation of drift in marginal lower velocity (depositional) habitats, analogous to higher vehicle densities as traffic slows in congested traffic (Anderson, Harrison, Nisbet, & Kolpas, 2013). However, evaluating these competing mechanisms would require vertical profiles of drift concentration (e.g., Cienciala & Hassan, 2018; Stark, Shearer, & Hayes, 2002) or measuring drift settling rates in different habitats.

Our results also highlight the temporal stability of daytime aquatic drift relative to drift of terrestrial origin. The short duration drift sets typically used in larger rivers may poorly integrate temporal variation

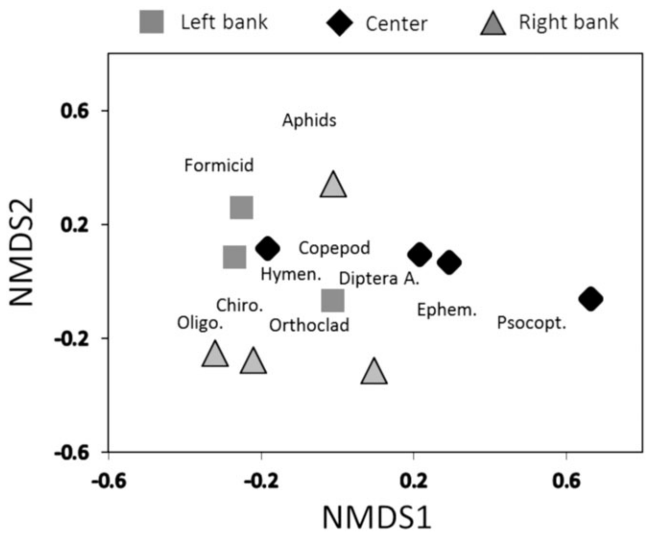

FIGURE 4 Nonmetric multidimensional scaling ordination plot of drift samples from the Fraser River. Circles represent centre-channel (thalweg) samples, and triangles and squares represent samples collected from the right and left wadeable river margins, respectively. Text labels represent loadings of taxa in the ordination space. Diptera A. = small adult flies, Chiro = adult chironomids, Ephem. = mayfly nymphs, Formicid = winged ants, Hymen. = Hymenoptera (small parasitic wasps), Oligo. = small oligochaetes, Orthoclad = Orthocladiinae chironomid larvae, and Psocopt. = adult Psocopterans

in drift abundance, even though they filter a volume of water that may exceed much longer duration samples collected in smaller low-velocity streams. This is illustrated by the strong temporal trend in terrestrial invertebrate abundance throughout the day associated with dispersing winged ants (Figure 3). However, there is no corresponding temporal trend for aquatic drift, suggesting that drift of terrestrial origin may be the more variable metric.

If invertebrate drift does vary transversely across a river channel (Weber et al., 2017), then a more intensive transverse sampling design may be needed to precisely calculate drift flux (e.g., Miller & Judson, 2014). Nevertheless, near-shore sampling in this study appears to collect drift that is broadly representative of overall abundance and should be suitable for characterizing drift concentration in landscape-scale surveys where drift abundance can vary by an order of magnitude (Weber et al., 2017) or in rapid surveys of poorly accessible boulder-bed channels. Sampling invertebrate drift across the wide range of conditions present in running waters is challenging, and the method described here should provide a useful additional tool.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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