Ecography

ECOG-04597

Siebers, A. R., Paillex, A. and Robinson, C. T. 2019. Flow intermittency influences the trophic base, but not the overall diversity of alpine stream food webs. – Ecography doi: 10.1111/ecog.04597

Appendix 1

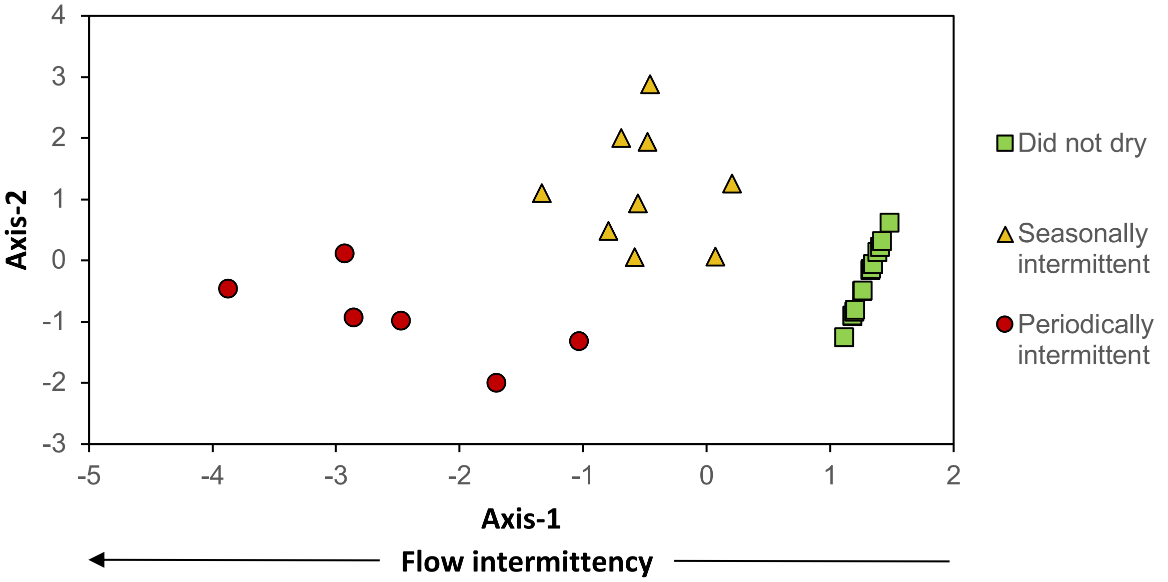

Figure A1. Ordination of principal components analysis (PCA) of flow presence/absence data from electric conductivity loggers installed across 28 headwater streams of Val Roseg. Sites are ordinated based on presence/absence of dry periods, total duration of dry periods (hours), length of individual drying periods (hours), and the timing of dry periods (skew of drying events distribution). Seasonally intermittent sites only dried during autumn (September–October), while periodically intermittent sites also dried during summer (July–August).

Methods A1

Calculation of isotopic niche indices

We calculated three complimentary metrics of food web size using indices of isotopic niche width (Layman et al. 2007). For total food web size, we calculated the size of standard ellipse areas (SEA) for each site in δ^{13}C and δ^{15}N isotope space, which encapsulates a consistent proportion of data points within groups regardless of sample size (Jackson et al. 2011). We restricted our analysis of SEA to streams with ≥ 5 macroinvertebrate samples (Jackson et al. 2011). These measures were calculated using the package SIBER in R ver. 3.4.2 (<www.r-project.org>). SEA values presented are corrected for sample size (SEAc). Next, we calculated the height of food webs as food chain length (FCL) using the maximum minus the minimum trophic position (TP) of macroinvertebrates within each site (Post 2002a). TP was calculated for each consumer sample as $\mathrm{TP} = \lambda + (\delta^{15}\mathrm{N}_{\mathrm{consumer}} - \delta^{15}\mathrm{N}_{\mathrm{base}})/\Delta\delta^{15}\mathrm{N}$ (Post 2002b), where $\lambda = 2$ (i.e., the trophic position of primary consumers), $\delta^{15}\mathrm{N}_{\mathrm{base}}$ is the δ^{15}N value for *Baetis alpinus* mayfly larvae within the same stream, and $\Delta\delta^{15}\mathrm{N} = 3.4$ (i.e., the mean trophic enrichment factor (TEF) rate assumed for consumers; Post 2002b). *Baetis* mayflies were chosen as examples of base δ^{15}N (as in McHugh et al. 2015) due to their well-described roles as primary consumers in Swiss streams (Bauernfeind et al. 2002) and their presence across most sites. Where *Baetis* were not found, we used the lowest δ^{15}N value of other probable primary consumers present (e.g., Simuliidae; n = 4). Finally, we characterized food web breadth by calculating the range of δ^{13}C values for macroinvertebrates at each site ($\mathrm{C}_{\mathrm{range}}$, *sensu* Layman et al. 2007). Uncertainty can arise from $\mathrm{C}_{\mathrm{range}}$ comparisons across sites with different resource δ^{13}C signatures (Newsome et al. 2007). However, CPOM, periphyton, and FPOM δ^{13}C signatures were relatively consistent across sites (see: Results). Consequently, we did not standardize $\mathrm{C}_{\mathrm{range}}$ values before further analyses.

Methods A2

Isotope mixing model analyses

We used mixing models to estimate the dietary contributions of basal food resource groups to primary consumers. Initially, we tested whether primary consumer isotope values could be suitable for use with mixing models using the Monte Carlo simulation of the possible range of isotopic mixing models developed by Smith et al. (2013). A total of 1500 iterations were performed, with sources corrected by ranges for TEF: for δ^{13}C, 0.4 ± 0.3, and for δ^{15}N, 2.2 ± 0.3 (Post 2002a, McCutchan et al. 2003). All data fell within the 95% confidence bounds, indicating suitability for mixing model analysis (Smith et al. 2013, Philips et al. 2014). Consequently, we used the Bayesian mixing model SIAR (Parnell et al. 2010) to produce probability distributions of the contributions of basal resources to consumer isotope values. Given that underdetermined mixing models are biased towards priors (Fry 2013, Brett 2014), we reduced basal resources to three source points via combinations of ecologically and isotopically similar sources (e.g. terrestrial plant leaves and aquatic CPOM; Philips et al. 2005). We did not include prior information on diet proportions, as a) we had already reduced sources in the mixing model to 3 (Fry 2013, Brett 2014) and b) alpine species can vary their diet considerably from expected proportions in response to environmental pressures (Zah et al. 2001). We ran the model separately for each consumer sample. CPOM and FPOM δ^{13}C and δ^{15}N values were set as averages for all sites. Periphyton δ^{13}C values were set at site-specific values. The model was set to run 500 000 times, with the first 50 000 iterations discarded. All models were created using the SIAR package in R ver. 3.4.2 (<www.r-project.org>).

We present the upper and lower quartiles of model results together with the median, which we further used in predictive modelling (generalised additive models; see Material and methods: Data analysis). Where multiple primary consumers existed per site, we took quartiles and medians of the entire range of SIAR results from each site. We acknowledge that SIAR results are probability distributions, thus the true values of dietary contributions could theoretically occur anywhere within the simulated ranges of values (Philips et al. 2014). However, the medians provide an estimation of central tendency which, given the consistent standard deviation of simulation results across all runs (mean ± SD, 0.13 ± 0.03), provides a consistent indication of possible dietary contributions.

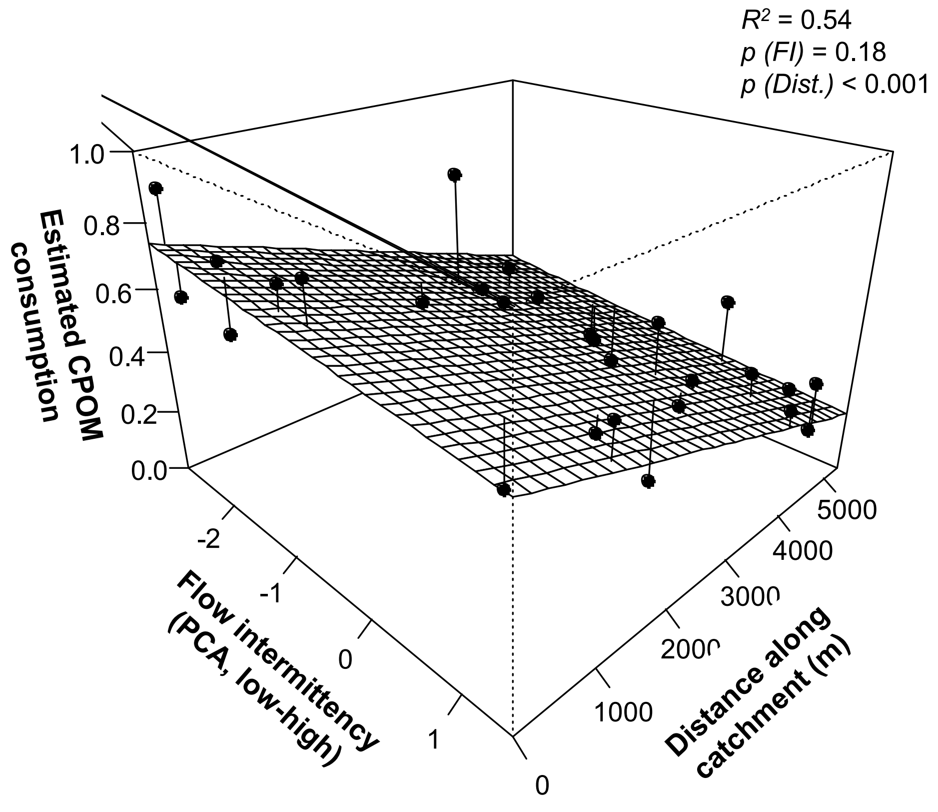

Figure A2. Three-dimensional plots of generalized additive model (GAMs) predicting median estimated coarse particulate organic matter (CPOM) consumption by primary consumers in relation to flow intermittency and distance from the head of the catchment. Original data points and residuals relative to GAM fitted values are also shown. R^2-values are adjusted for sample size. FI = flow intermittency. Dist. = distance along catchment.

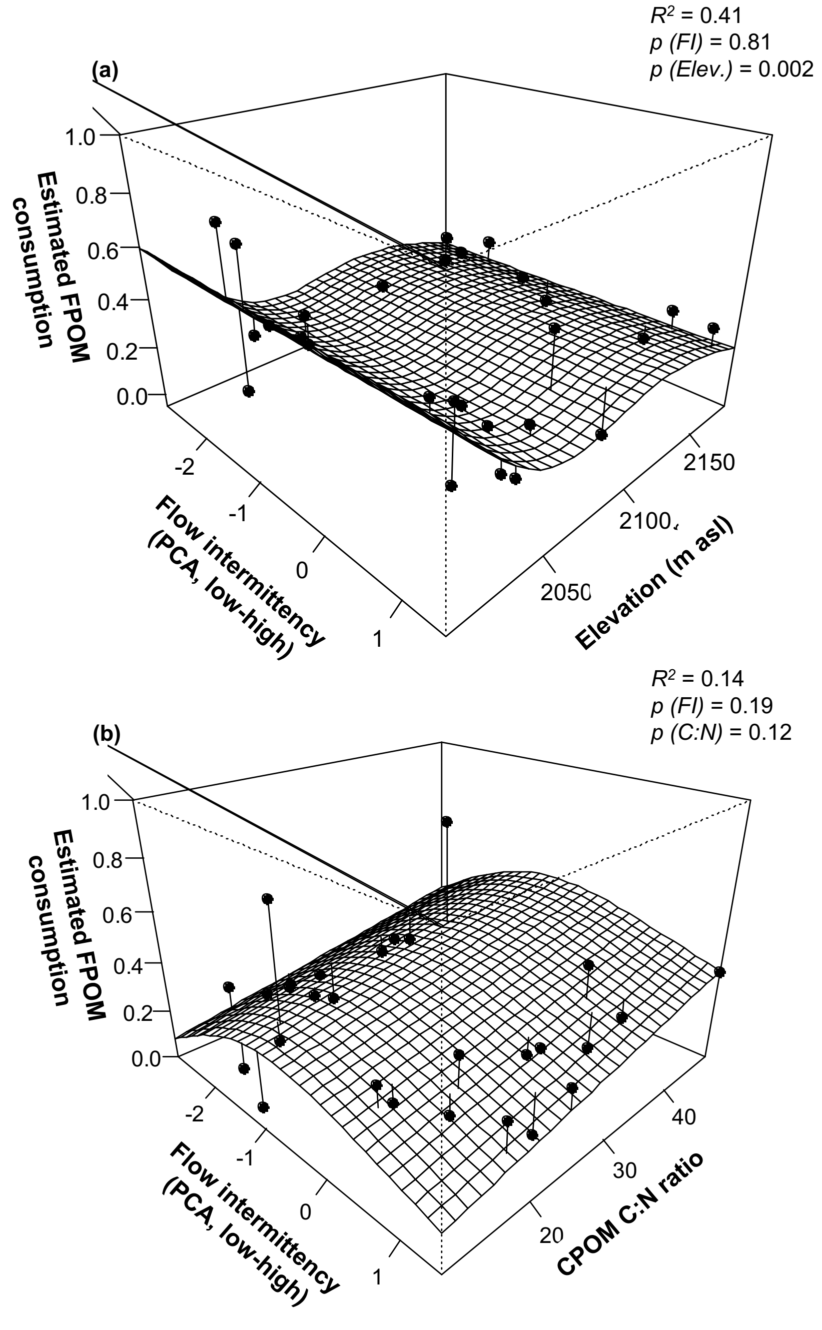

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Figure A3 Three-dimensional plots of generalized additive model (GAMs) predicting median estimated fine particulate organic matter (FPOM) consumption by primary consumers in relation to flow intermittency and (a) site elevation and (b) CPOM C:N ratios. Original data points and residuals relative to GAM fitted values are also shown. R^2-values are adjusted for sample size. FI = flow intermittency. Elev. = elevation. C:N = CPOM C:N ratio.

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