Response of protozoan communities in stream biofilms to urban and agricultural land-use impacts

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Biofilms in streams may look slimy and insignificant but current estimates suggest that 99% of microbial activity in freshwater occurs within surface-associated communities. These biofilm "hot spots" play an important ecological role in aquatic environments where they provide a wide variety of ecosystem services including organic matter processing and retention and cycling of nutrients through microbial-mediated processes. Bacteria in particular contribute substantially to these processes and much of their biomass, activity and function are concentrated in biofilms. Biofilms are also intensively grazed by protozoa (microfauna) as well as macrobenthic fauna. These grazing activities significantly affect the functioning of biofilms by altering community composition influencing the efficiency of nutrient uptake, increasing turnover rates and so maintaining the biofilm in an active growth phase. In high productivity environments, protozoan grazing is considered one of the most important factors regulating bacterial productivity and community structure. In streams, biofilm-grazing protozoa particularly ciliates contribute to the carbon and energy transfer from biofilm to higher trophic levels by stimulating the decomposition of organic

Despite their importance in biofilm communities however, the role protozoa play in the delivery of ecosystem services is poorly understood, especially in nutrient impacted and urban degraded environments. We surveyed and characterised protozoan community structure associated with stream biofilms with contrasting land use in four NZ streams. Our sites ranged from a near pristine stream in native bush to moderate and heavily-impacted streams, influenced by agricultural and urban pollutants respectively. Two methods to collect biofilm samples *in-situ* were trialled and the results compared. The study found significant biodiversity differences between ciliate protozoan communities in stream biofilms associated with different land uses. Trends were observed with ciliate diversity increasing from the least impacted stream to highest diversity found in moderately to highly impacted streams. This trend contrasted with that found for macrobenthic invertebrates. Less than 10% of ciliate taxa identified were common to all 4 sites but cosmopolitan taxa were more abundant than taxa with restricted spatial distributions. Potential ciliate species are being investigated as possible indicators of ecosystem health.

Different types of ciliate protozoa are known to have different tolerances to pollution and different land uses may cause development of different biofilm-associated ciliate communities by favouring tolerant taxa while discriminating against more sensitive taxa. Elevated nutrient and sunlight availability in streams characteristic of agricultural and urban land-use impacts, can also increase biofilm biomass and promote the growth of autotrophic biofilm organisms. This can lead to a greater variety and abundance of biofilm-related food resources and feeding niches for protozoa. Increased biomass and more diverse bacterial and algal biofilm communities observed in the two most impacted streams in our studies may therefore have contributed to the development of a greater diversity and abundance of bacterivorous, algivorous and predacious ciliates found associated with biofilms from these streams. The response of stream biofilm protozoan communities to land-use impacts suggests that protozoan communities may be a more sensitive indicator of ecological change in highly impacted environments compared to macroinvertebrate communities.

Our understanding of the ecological role of protozoan communities in structuring stream biofilms is also limited. Investigations into the influence of protozoan grazers on stream biofilm composition have been carried out through studies on feeding preferences and grazer mechanisms. Our results suggest that grazing by several biofilm associated ciliates with contrasting morphology, motility and feeding strategies may have a range of impacts on biofilm bacteria communities with grazing activities contributing to the development of spatial, morphological and population heterogeneity in stream biofilms.

Together, these studies contribute to furthering our understanding of the biodiversity dynamics of microbial stream biofilms and their functional relationships with grazing protozoa. In addition to complementary studies on macroinvertebrates at the same stream sites, we are developing a greater understanding of ecosystem functioning in streams from catchments with varying land use impacts.