

Fourth Year Committee Report

Sarah Stevens, McMahon Lab

Meeting: October 27th, 2015 in MSB 6503

I am interested in understanding how bacterial populations diversify and form species. My work aims to better understand the forces that shape bacterial population structure using the lakes as a model system. The McMahon Lab metagenomic time series of many lakes is an ideal dataset for investigating how wild bacterial populations change through time.

Research Progress

The manuscript I submitted last year has been published in ISMEJ. This work shows evidence for both of the two major models of bacterial speciation by tracking single-nucleotide variants in populations of bacteria using 30 metagenome-assembled genomes (MAGs) and a metagenomic timeseries containing 63 samples over 6 years. We found that one population showed a genome-wide loss of diversity where others had seen a reduction in diversity for only a particular region of the genome. This suggests that co-existing populations in the lake have a high selection to recombination ratio where others have a low selection to recombination ratio.

In the past year, I have also worked on the population dynamics of many dominant freshwater bacteria, focusing on two groups (which represent roughly family level) for which we have multiple single-amplified genomes (SAGs) and sequence-discrete populations. Genetically distinct populations within roughly species level groups of the acI actinobacterial lineage living in the same lake had different seasonal abundance patterns, suggesting these populations were also ecologically distinct. In contrast, sympatric LD12 alphaproteobacterial populations were much less genetically differentiated and had similar temporal abundance patterns. This suggests that within one lake, some freshwater lineages harbor genetically discrete (but still closely related) and ecologically distinct populations, while other lineages are composed of less differentiated populations with overlapping niches. I have submitted the manuscript for this project on bioRxiv, a biology preprint server and it will soon be submitted to Nature Communications.

The manuscripts for both of these projects are attached to this report.

New Questions

I continue to be interested in discerning the forces shaping wild bacterial populations and would like to turn my focus from the whole genomes of populations to their gene content.

How does selection differ when you look at it within vs between sequence-discrete populations? Does selection act differently on homologous genes shared by different populations? Which traits are under strong selection? I plan to compare how calculations of selection across environments (very broad scale) compares with calculations of selection between and within (very fine scale) sequence-discrete populations in the same environment. I will search for metrics of selection which are appropriate for my dataset and be comparable across scale. Once these metrics are calculated, I will identify homologous genes in different populations and search for patterns of selection among the homologs. I expect that some genes may be under strong selection, regardless of the population they are in. Finding such genes should identify traits under strong selection in each lake.

Are there related sequence-discrete populations in TB and CB? How closely related are they? Do they share a common gene pool? Are there genes present in one lake but not the other for these closely related populations? Is there an ecological or physical barrier to recombination between these two lakes? We now also have Crystal Bog metagenomes and can bin MAG's from Crystal Bog (CB), which is of similar location and trophic status to Trout Bog (TB), where our previous MAGs were from. I will bin MAGs from the CB assemblies and use new techniques to get more MAGs from the TB assemblies. With these genomes, I will search for very closely related genomes and quantify how similar they are across their genomes. For genomes that are very closely related (>95% nucleotide identity across their shared genome content), I will also investigate if the associated populations share a common gene pool between the two lakes. By mapping the metagenomes from one lake to MAGs from the other, I will identify if there are regions or genes that are present in only one of the lakes and if the diversity of shared genes is different between the two lakes. I will search for patterns among the shared or

absent genes that may be explained by the different environments of the two lakes. I will also look for evidence of a barrier to recombination between these allopatric populations.

Publications

Garcia, S. L.*, **Stevens, S. L. R.***, Crary, B., Martinez-Garcia, M., Stepanauskas, R., Woyke, T., Tringe, S. G., Andersson, S., Bertilsson, S., Malmstrom, R., McMahon, K. D. (*in prep for Nature Communications*). Contrasting patterns of genome-level diversity across distinct co-occurring populations. doi:<http://dx.doi.org/10.1101/080168>
Bendall, M. L.*, **Stevens, S. L. R.***, Chan, L.-K., Malfatti, S., Schwientek, P., Tremblay, J., Schackwitz, W., Martin, J., Pati, A., Bushnell, B., Froula, J., Kang, D., Tringe, S. G., Bertilsson, S., Moran, M. A., Shade, A., Newton, R. J., McMahon, K. D., Malmstrom, R. R. (2016). Genome-wide selective sweeps and gene-specific sweeps in natural bacterial populations. ISMEJ. doi:<http://dx.doi.org/10.1038/ismej.2015.241> **featured article**

*Equal contributors

Oral Presentations

Stevens, S. L. R., Bendall, M. L., Chan, L.-K., Malfatti, S., Schwientek, P., Tremblay, J., ... McMahon, K. D. Malmstrom, R. R. Tracking Microbial Populations Through Time Using Single-cell Genomes and Metagenomics. UW Center for Limnology Seminar. December 2015. Madison, WI. <https://goo.gl/0ge2LZ>

Stevens, S. L. R., Bendall, M. L., Chan, L.-K., Malfatti, S., Schwientek, P., Tremblay, J., ... McMahon, K. D. Malmstrom, R. R. Genome-wide and Gene-specific Selective Sweeps in Freshwater Bacterial Populations Revealed Using Metagenomics. JF Crow Institute for the Study of Evolution Seminar Series. October 2015. Madison, WI. <https://goo.gl/oSnDYG>

Poster Presentations

Stevens, S. L. R., Garcia, S. L. ... McMahon, K. D. Contrasting patterns of genome-level diversity across distinct co-occurring populations. 16th International Symposium on Microbial Ecology. August 2016. Montreal, Canada. <https://goo.gl/6iunz0>

Stevens, S. L. R., Garcia, S. L. ... McMahon, K. D. Tracking distinct freshwater populations through time by mapping metagenomes to single-cell genomes. DOE Joint Genome Institute User Meeting 2016. Walnut Creek, CA. <https://goo.gl/ShUQVn>

Professional Development

- Software/Data Carpentry
 - Taught 4 Software Carpentry Workshops (2 on-campus, 2 off-campus)
 - Helped with 2 Data Carpentry Workshops on-campus
 - Helped with Instructor Training on-campus
- Computational Biology, Ecology, and Evolution(ComBEE) support group - Started Nov. 2014
- ComBEE Python Study Group - Started Dec. 2014
- ComBEE R Study Group - Started Fall 2015
- MDTP Steering Committee - 2015-2016

Awards

- UW-Madison Dept. of Bacteriology Betley-Allen Fellowship - 2016-2017
- UW-Madison Graduate School Travel Award - Fall 2015