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Genetic diversity of lichen photobionts and related organisms

An In-Depth Look at the Diversity of Symbiotic Nostoc

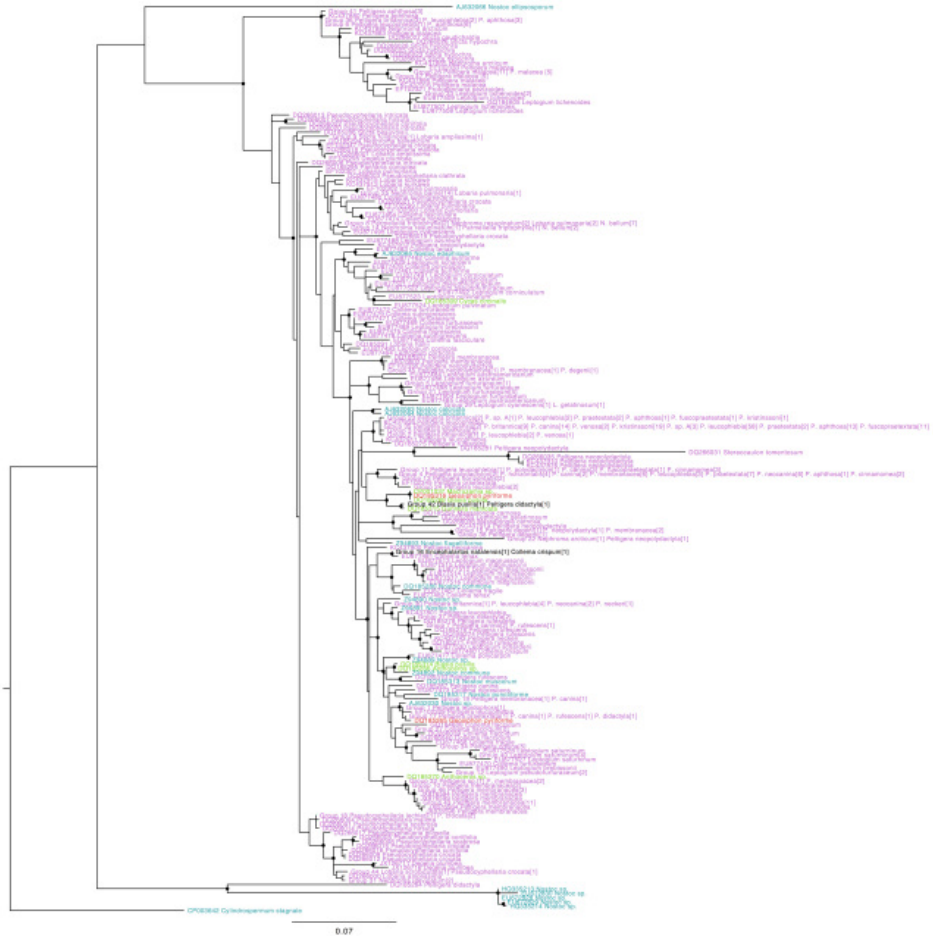
Posted on May 8, 2013

****Post has been updated with some corrections to the host information in the first phylogeny****

Today I am finally going to take a detailed look at the *Nostoc* phylogeny that I have been working on. But before I can begin, I have to figure out a way to highlight interesting taxa in an automated way. To do this, I wrote a script that adds html color tags after taxon names according to various classifications. While I was at it, I converted the branch support values to a binary system (≥0.9 vs. <0.9), which I can display as black circles on significantly supported branches. Note that this script requires that the tree be in NEXUS format rather than the plain Newick that is produced by PhyML. Opening the tree file in FigTree and saving it converts it to NEXUS, or the conversion could be scripted using Bioperl.

First, lets compare lichen photobionts to other free-living and symbiotic *Nostoc* strains:

../Scripts/ColourTree.pl ../Nostoc_rbcX_metadata.txt ../Nostoc_rbcX_host.nwk host >host_tree.nwk

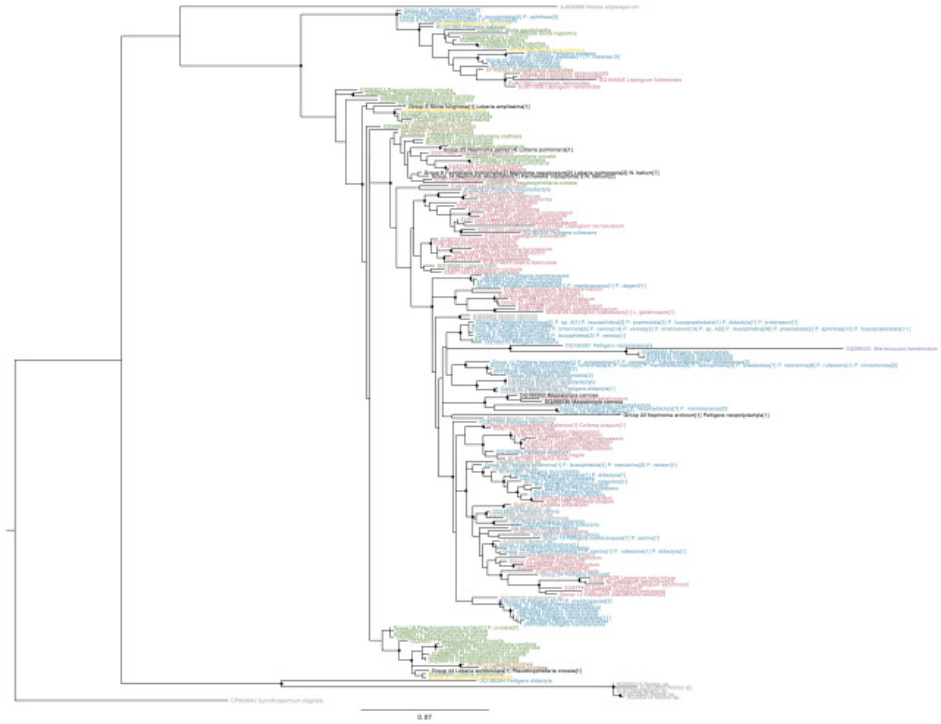


Nostoc rbcX phylogeny, coloured by type of association (purple: lichen photobionts, green: plant symbionts, blue: free-living, red: fungal endosymbiont). Names in black indicate genotypes found in more than one group. Circles on internal nodes indicate aLRT ≥0.9.

As mentioned last time, the earliest branching taxa are free-living *Nostoc* isolates, along with a culture isolated from *Peltigera*, which I suspect may not be a true photobiont. There are also other free-living strains throughout the rest of the phylogeny that have been identified as *N. edaphicum, N. calcicola, N. commune, N. muscorum and N. flagelliforme*. Cyanobacterial taxonomy is a mess, but that is a topic for another day. There are also symbionts from a variety of plant groups throughout the main crown group including Cycads (Cycas, *Macrozamia* and *Encephalartos*), Bryophytes (*Blassia* and *Anthoceros*) and the angiosperm *Gunnera*. There are two cases where lichen photobionts are identical to plant symbionts (coloured black in the tree). Finally, there are two symbionts from *Geosiphon pyriforme*, a weird unicellular primative fungus, that hosts intracellular symbionts in sac-like, multinucleate cells (coloured red). There is some debate as to whether this symbiosis should be classified as a lichen or not.

Next, we can look at photobionts of different lichen families (the taxonomy of the lichen is based on that of the fungal partner):

../Scripts/ColourTree.pl ../Nostoc_rbcX_metadata.txt ../Nostoc_rbcX_host.nwk family >family_tree.nwk

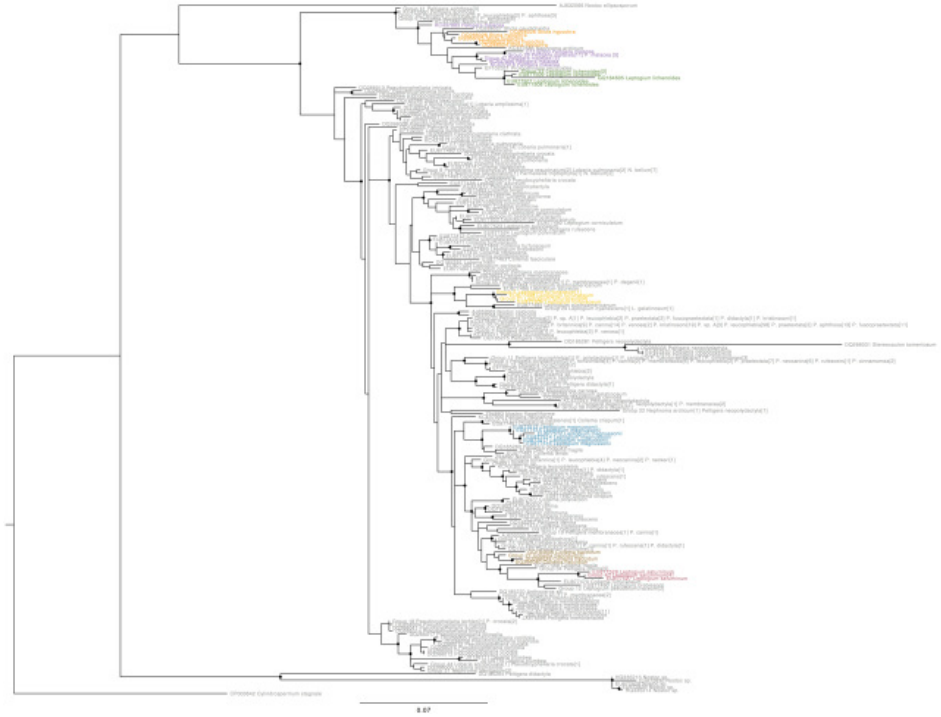


Nostoc rbcX phylogeny, coloured by host family (purple: Stereocaulaceae, green: Lobariaceae, blue: Peltigerales, red: Collemetaceae, yellow: Nephromataceae, brown: Pannariaceae). Names in black indicate genotypes found in more than one group or photobionts of lichens with uncertain taxonomic position (*Massalongia*). Names in grey indicate non-lichenized strains. Circles on internal nodes indicate aLRT ≥0.9.

At the deepest nodes in the tree, there is clearly a lot of host switching between different lichen families, but there is a lot of clustering of photobionts from the same lichen family at the tips of the tree. Photobionts of lichens in the Lobariaceae, Nephromataceae and Pannariaceae are all mixed up, which has been noted previously and has been proposed to reflect the ecological similarities of the hosts. There also appears to be a lot of historic photobiont sharing between lichens in the Peltigeraceae and the Collmenataceae, but such sharing is not ongoing as in all cases there are long branches separating photobionts of these families. *Stereocaulon* is the only species represented in the tree that is not part of the Peltigerales, an order of lichens that are universally associated with *Nostoc*, either as the sole photosynthetic partner or as a secondary photobiont. It would be interesting to see if other non-Peltigeralean lichens also associate with such divergent *Nostoc* genotypes.

Lastly, let's take a look at species-level patterns. There is a lot of host switching among members of the same genus, but there do appear to be some species that are highly specialised:

../Scripts/ColourTree.pl ../Nostoc_rbcX_metadata.txt ../Nostoc_rbcX_host.nwk specialists >specialist_tree.nwk



Nostoc rbcX phylogeny, coloured by host species Names in grey indicate non-specialist hosts. Circles on internal nodes indicate aLRT ≥0.9.

With the current sampling, it is possible to identify four species of *Leptogium* and one each of *Collema, Peltigera and Sticta* that exclusively associate with a single cluster of photobionts, which is, in turn, exclusively associated with that lichen species (reciprocal specificity). Note that there is one *P. malacea* photobiont that falls out of the *P. malacea* cluster, but there are about four times as many specimens of this species as there are for any of the other specialists. As noted previously, these specialists predominate in the basal symbiotic *Nostoc* lineage.

There is a lot more that could be said about this tree, but I think I'll leave it there for now. See this paper for a more detailed analysis of the complex photobiont specialisation patterns in *Peltigera*, including geographic patterns. On to the green algal photobionts in my next post…

This entry was posted in Uncategorized and tagged Nostoc. Bookmark the permalink.

2 Responses to *An In-Depth Look at the Diversity of Symbiotic Nostoc*

Daniel Henk *says:*
May 15, 2013 at 11:05 am

Hey that's looking pretty good. How about linking that up to research blogging?

Reply

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