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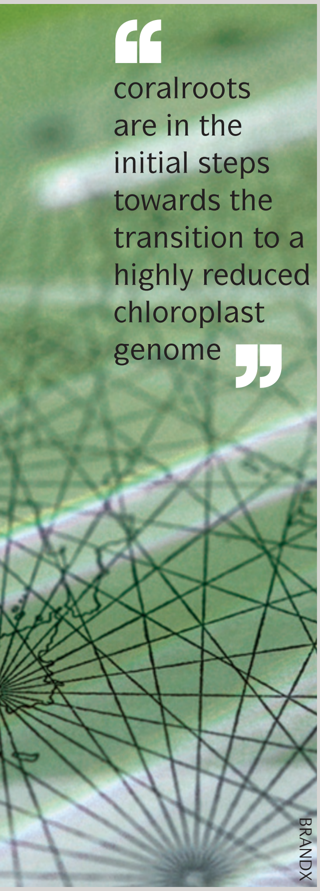
PLANT GENETICS

Following the early root of plastome degradation



Parasitic organisms are often genomically and morphologically reduced. For example, some parasitic plants contain degraded plastid genomes owing to a reduced need to photosynthesize. A new study now shows that coralroot orchids are in the early stages of the transition to a parasitic lifestyle, and that this condition has arisen independently at least twice in the genus.

Most coralroot orchids do not have leaves, produce little chlorophyll and depend on fungi to obtain nutrients. This lifestyle is a form of myco-heterotrophy, which has evolved independently many times. “All orchids associate with fungi in the earliest stages of their life cycles, but coralroots take this to a new level,” explains Craig Barrett, lead author of the study. “Coralroots associate with ectomycorrhizal soil fungi, which are in turn mutualists with surrounding trees and thus coralroots ‘embezzle’ sugar, water and nutrients from this pre-existing mutualism between fungi and trees.”

To gain insights into the early stages of the transition to parasitism, the researchers isolated chloroplast DNA from nine species of coralroot orchids for high-throughput sequencing. *De novo* assembly was then used to piece together the genomes and to define genes and pseudogenes. In addition, chlorophyll content was measured for several plants from each species. Some coralroot orchids have green tissues, and it is thought that these species are still able to photosynthesize, whereas those without any green tissues cannot.

The authors report a correlation between the number of functional chloroplast genes and chlorophyll content in the coralroot species. Notably, non-green coralroots still produce chlorophyll, but at 10-fold lower concentrations. Analyses of whole chloroplast genomes for the coralroots showed that fewer functional loci were found in the non-green species than green coralroots. In addition, most of the plastid genomes were lacking functional genes from the NAD(P)H complex, which is involved in chlororespiration. There have been at least two independent losses of photosynthesis in the genus — as inferred from the gene deletions and the presence of pseudogenes in both *Corallorhiza Striata* and *Corallorhiza maculata*.

Notably, in accordance with the team’s earlier hypothesis on the specific stepwise progression of gene loss in heterotrophic flowering plants (NAD(P)H genes followed by photosynthesis-related genes, plastid-encoded RNA polymerase genes, ATP synthase genes and housekeeping genes), coralroots are in the early stages of genome degradation. This study indicates that a specific path does seem to exist for plastid genome degradation (with some exceptions) and that coralroots are in the initial steps towards the transition to a highly reduced chloroplast genome, which is typical of obligate parasites. “This condition has arisen independently at least twice in the genus, making coralroots a powerful system in which to study the transition to parasitism,” explains Barrett.

The team now plan to explore the nuclear genomes of heterotrophic plants, such as coralroot orchids. “Future genomic studies in these unique plants will provide a novel perspective on parasitism and should lead to the development of tools that can be used in conservation of these often rare or threatened plants,” he concludes.

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ORIGINAL RESEARCH PAPER Barrett, C. F. *et al.* Investigating the path of plastid genome degradation in an early-transitional clade of heterotrophic orchids, and implications for heterotrophic angiosperms. *Mol. Biol. Evol.* http://dx.doi.org/10.1093/molbev/msu252 (2014)