




Parallel Miocene dispersal events explain the cosmopolitan distribution of the Hypogymnioid lichens

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Funding information

National Natural Science Foundation of China, Grant/Award Number: 31770022; the Spanish Ministerio de Economía y Competitividad, Grant/Award Number: CGL2013-42498-P; Ministry of Science and Technology of China, Grant/Award Number: 2014FY210400

Editor: Dr. Vincent Merckx

Abstract

Aim: Contemporary species' distributions are shaped by both geography and historical events, such as extinction, diversification in specific areas and long-distance dispersals. In the most diverse family of lichen-forming fungi, Parmeliaceae, the Hypogymnioid clade, is an example of an evolutionary lineage comprised of species occurring in temperate to subpolar regions in both hemispheres. Here, we elucidate the timing of diversification events and the impact of historical events on the species distribution in this lineage.

Location: Worldwide.

Taxon: Genera *Arctoparmelia*, *Brodoa*, *Hypogymnia* and *Pseudevernia* (Parmeliaceae).

Methods: Our sampling focused on the most diverse genus of the clade, *Hypogymnia*, including c. 70% of the described species. We reconstructed phylogenetic relationships using a multi-locus data set, estimated divergence times, and inferred ancestral distributions.

Results: Our analyses suggest that the ancestor of the Hypogymnioid clade occurred in the Holarctic. In each of the four genera, all recovered as monophyletic here, diversification have occurred largely during the Miocene and Pliocene. A number of currently accepted species did not form monophyletic groups, especially in cases where specimens were collected from distinct geographic areas, with multiple, distinct clades corresponding to the geographic region of origin. Our results suggest that only a very few species in the Hypogymnioid clade have cosmopolitan distributions, all of which reproduces using vegetative propagules including both symbiotic partners.

Main conclusions: While the diversification occurred predominantly in the Northern Hemisphere during the Miocene, a long-distance dispersal event from the Northern to the Southern Hemisphere, resulted in diversification of a clade of species largely restricted to the Southern Hemisphere. Similar to other groups in this diverse family, our study highlights the need for re-evaluation of species boundaries among members of the Hypogymnioid clade.

KEYWORDS

Biogeography, diversification, *Hypogymnia*, lichen, Miocene, molecular evolution, molecular systematics, substitution rate