How ferns adapted to one of Earth's newest and most extreme environments

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Ferns are believed to be 'old' plant species – some of them lived alongside the dinosaurs, over 200 million years ago. However, a group of Andean ferns evolved much more recently: their completely new form and structure (morphology) arose and diversified within the last 2 million years. This novel morphology seems to have been advantageous when colonising the extreme environment of the high Andes.

Dr Patricia Sanchez-Baracaldo (Bristol) and Dr Gavin Thomas (Sheffield) used molecular and morphological data to study a group of ferns which grow in a unique ecosystem of the Andean mountains.

This ecosystem, known as the páramo, was created relatively recently (around 3 to 5 million years ago), when the Andes underwent a major uplifting event. This provided new ecological opportunities for plants to exploit and flourish in. Other plants from North America and temperate southern regions were also able to colonise these new páramo environments.

In contrast to the archetypal tropical rainforest, where trees are tall and some plants have huge leaves, the páramos are more exposed, tundra-like biomes where plants are short and have much smaller leaves, some of which are very hairy.

Higher altitudes near the equator experience extreme environmental fluctuations every twenty-four hours, with very cold nights and very hot days. In order to grow there, some plants have evolved new adaptions, in

form and in leaf structure, which allow them to cope with the paramos' freezing nights and high solar radiation at midday.

The Bristol and Sheffield team found that one group of páramo ferns evolved highly modified leaves, which retain the furled fronds of a young fern yet are sexually mature. Some páramo species were found to have over 300 pairs of leaflets per frond – this is in contrast to their closest relatives in the more sheltered habitat of the cloud forest, lower down the mountains, which have no more than 12 pairs of leaflets per frond. In addition, the length of these leaflets declines rapidly with the increase in altitude.

The researchers also found that the rate by which new biological species arise (speciation) is significantly higher among páramo than non-páramo ferns.

Dr Sanchez-Baracaldo of Bristol's School of Geographical Sciences said: "These ferns are remarkable because, in geological terms, they quickly evolved a new morphology as a response to new and extreme environmental conditions. It's fascinating to notice that, by a process known as convergent evolution, whereby similar features evolve independently in species of different lineages, cloud forest ferns arrived at the same 'solution' in response to the same environmental pressures."

More information: 'Adaptation and convergent evolution within the Jamesonia-Eriosorus complex in high-elevation biodiverse Andean hotspots' by Patricia Sánchez-Baracaldo and Gavin H. Thomas in *PLOS ONE*.

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