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Integrative Taxonomy Uncovers Six New Foliicolous Lichen Species and Cryptic Symbiont Networks Across Southwestern Indian Ocean Islands

Ecology & Evolution * Mycology * Lichens

On the humid, evergreen leaves of tropical rainforest understories, an entire microscopic ecosystem thrives directly atop the waxy leaf cuticle [1, 2] . Known as foliicolous lichens , these specialized symbiotic organisms -- composed of a lichenized fungus (the mycobiont) paired with photosynthetic green algae (the photobiont) -- must germinate, mature, and reproduce within the finite lifespan of a single host leaf [1, 3] . Despite their ecological ubiquity as sensitive bioindicators of forest microclimate and atmospheric humidity, foliicolous lichens across the southwestern Indian Ocean have remained severely understudied compared to those of the Neotropics [1, 2] .

In a comprehensive systematic study published in IMA Fungus , mycologists Sandro Debaene, Luca Borgato, and Damien Ertz bridged this biodiversity gap by applying an integrative taxonomic framework to the lichen family Porinaceae (Ascomycota , order Ostropales) across Madagascar, Mauritius, and Mayotte [1, 2] . Analyzing 114 freshly collected specimens through combined microscopic morphometrics and multi-locus phylogenetics , the researchers cataloged 37 distinct Porinaceae taxa and formally described six species entirely new to science , while mapping the hidden genetic diversity of their green algal partners [1, 2] .

1. The Epiphyllous Lifestyle and the Limits of Classical Morphology

Historically, lichen taxonomy relied heavily on macroscopic thallus architecture and light-microscopic measurements of reproductive fruiting bodies (perithecia) and ascospore septation [1, 3] . In foliicolous Porinaceae, however, strict reliance on morphology frequently conceals cryptic evolutionary lineages [1] :

* Convergent Phenotypic Minimalism: Because foliicolous lichens colonize an ephemeral, two-dimensional substrate -- living angiosperm and fern leaves -- natural selection favors rapid life-cycle completion and minimal biomass investment [1, 3] . Many unrelated species converge on nearly indistinguishable, paper-thin crustose thalli studded with tiny, flask-shaped perithecia.

* Substrate-Induced Plasticity: Minor variations in leaf surface topography, shade intensity, and cuticle chemistry within tropical forests can alter thallus color, crystal deposition, and perithecial hairiness, causing distinct genetic lineages to look identical or single species to appear artificially variable [1] .

* Historical Sampling Bias: While Neotropical foliicolous lichen floras have been intensively monographed for decades, the Mascarene and Comoro archipelagos -- alongside Madagascar's fragmented eastern rainforests -- remained largely represented by sparse, century-old herbarium collections unsuitable for modern DNA extraction [1, 2] .

* Accelerated Generation Turnover: Unlike rock-dwelling (saxicolous) lichens that persist for centuries, epiphyllous species must disperse, establish a symbiotic thallus, and mature perithecia within 12 to 36 months before leaf senescence occurs, favoring compact thalli and prolific asexual or ascospore dispersal [1, 3] .

2. Multi-Locus Integrative Taxonomy and the Six New Porina Species

To resolve species boundaries unambiguously, Debaene and colleagues integrated detailed anatomical characterization with multi- locus DNA barcoding of the fungal partner alongside chloroplast sequencing of the algal photobiont [1] . By sequencing nuclear ribosomal markers (ITS and nuLSU) and mitochondrial small-subunit ribosomal DNA (mtSSU), the team reconstructed a robust evolutionary phylogeny that decoupled true speciation from environmental plasticity [1] .

This integrative approach confirmed the presence of 37 Porinaceae species across the southwestern Indian Ocean islands and established six newly described species within the genus Porina [1, 2] :

| Newly Described Species | | Primary Island Distribution | | Key Diagnostic & Taxonomic Notes |

| Porina cincta (Debaene & Ertz) | | Southwestern Indian Ocean islands | | Distinguished by unique perithecial wall pigmentation and multi-locus phylogenetic placement [1, 2] . |

| Porina complanata (Debaene & Ertz) | | Southwestern Indian Ocean islands | | Characterized by flattened, closely appressed perithecia and distinct ascospore dimensions [1, 2] . |

| Porina madagascariensis (Debaene & Ertz) | | Madagascar | | Endemic Malagasy rainforest lineage resolved via combined ITS/mtSSU divergence [1, 2] . |

| Porina mayottensis (Debaene & Ertz) | | Mayotte (Comoro Archipelago) | | Island-restricted epiphyllous taxon demonstrating narrow archipelagic endemism [1, 2] . |

| Porina parva (Debaene, Diederich & Ertz) | | Southwestern Indian Ocean islands | | Cryptic miniature crustose species separated from lookalike relatives by molecular barcoding [1, 2] . |

| Porina trichocoronata (Debaene & Ertz) | | Southwestern Indian Ocean islands | | Diagnosed by a crown-like ring of sterile hyphal setae crowning the perithecial apex [1, 2] . |

3. Photobiont Diversity: Mapping Fungal-Algal Symbiosis via rbcL

A lichen is never a solitary organism ; it is a tightly integrated holobiont whose ecological tolerance depends on both its fungal scaffold and its photosynthetic partner [1, 4] . Lichens in the family Porinaceae associate predominantly with filamentous or discoid green algae of the order Trentepohliales (Ulvophyceae) -- most notably the epiphyllous genus Phycopeltis , which forms flat, circular discs on tropical leaves, and the filamentous genus Trentepohlia [1, 3, 4] .

By amplifying the plastid-encoded rbcL gene (encoding the large subunit of RuBisCO) directly from lichen thalli, Debaene, Borgato, and Ertz revealed a complex mosaic of

symbiotic specificity [1, 2] :

* Specialist vs. Generalist Associations: Some Porina lineages exhibit high photobiont fidelity, associating exclusively with tightly restricted clades of Phycopeltis algae adapted to deep-shade understory conditions [1, 4] . These discoid algae form single-layered, waxy-cuticle-hugging plates that resist rain-splash detachment while harvesting diffuse green-filtered light beneath dense tree canopies. Conversely, other mycobionts demonstrate ecological flexibility, recruiting distinct Trentepohlia or Phycopeltis genotypes across elevational or humidity gradients [1, 4] .

* Cryptic Algal Radiation: Just as fungal morphology conceals cryptic species, the rbcL phylogeny uncovered previously undocumented genetic diversity among tropical Indian Ocean trentepohlialean algae, demonstrating that island isolation drives parallel diversification across both partners of the symbiosis [1, 4] .

* Co-Dispersal vs. Horizontal Re-Lichenization: When foliicolous lichens reproduce sexually via multi-septate ascospores ejected from perithecia, the germinating fungal hyphae must locate and capture compatible free-living Phycopeltis algae already colonizing the leaf surface -- a stochastic encounter shaped by local algal pool diversity [1, 3, 4] .

4. Island Biogeography and Conservation of Tropical Micro-Habitats

The discovery of six new Porina species across Madagascar, Mauritius, and Mayotte underscores the extraordinary phylogeographic distinctiveness of the Malagasy and Mascarene biodiversity hotspot [1, 2] . Rather than consisting solely of wide-ranging pantropical weeds, southwestern Indian Ocean foliicolous lichen communities harbor localized island endemics shaped by oceanic dispersal barriers and ancient Gondwanan or Cenozoic geological histories [1] .

From a conservation standpoint, these findings carry urgent ecological weight. Because foliicolous lichens lack roots and obtain water and nutrients directly from mist, rainfall, and atmospheric humidity, they are extraordinarily sensitive to canopy opening, selective logging, and regional drying trends [1, 3] . In Mauritius and Madagascar, where intact native lowland and submontane rainforests have been reduced to fragmented remnants, preserving continuous forest microclimates is essential not only for charismatic lemurs and endemic birds, but also for the intricate, microscopic fungal-algal symbioses thriving on every rainforest leaf [1, 2] .

References & Primary Sources

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