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Impact of climatic niche on plant evolution: Systematic and phylogenetic comparative studies in *Miconia* sect. *Discolor* (Miconieae, Melastoamtaceae)

Introduction

Climate change can modify species' distribution and abundance in a few years, leading some of them to extinction [1]. Such influence on species survival makes climate a major component of ecological niche, the set of conditions that allow a positive growth rate of a giving species [2]. Regarding plants, niche's climatic dimensions (i.e. climatic niche) have great influence on survival, producing global patterns of correlation among different plant traits and climatic variables [3]. Indeed, climatic niche shifts can be followed by the evolution of morph-physiological novelties in plant lineages [4,5], indicating that climatic niche shifts can impose novel selective regimes to plant species. Beyond theoretical implications, understanding plant evolution under climatic niche shifts can optimize future conservation efforts by indicating lineages with greater chances of survival to climate change.

Miconia Ruiz & Pav. is a mega diverse genus (spp. > 2000), comprising tree and shrubs that are endemic to the Neotropics [6]. *Miconia* species are conspicuous elements of different vegetations, where they are pollinated by different insects [7] and provide food resource for mammals and birds [8,9]. Traditionally, *Miconia* taxonomy was based on floral morphology[10], but molecular-based phylogenetics has indicated that floral characters are not reliable to stablish an infrageneric classification within *Miconia*[11]. Indeed, geographical distribution holds greater phylogenetic signal within *Miconia*, since species diversity apparently results from invasions followed by radiations at different geographic regions (e.g. colonization of Carribean islands)[12].

In the Neotropical lowlands, *Miconia* species with discolor leaves and scorpioid or glomerulate inflorescence belong to *Miconia* sect. *Discolor* Caddah & R.Goldenb[13]. Species within this section occupy environmentally contrasting vegetations: the montane Atlantic rainforest, the seasonally dry Caatinga forest, the rocky outcrops of Cerrado savannas, and the Amazonian rainforest [13]. Giving the relatively recent climate change and climatic heterogeneity in Neotropical lowlands [14] , *Miconia* sect. *Discolor* is a model to understand if climatic niche shifts can impose novel selective regimes to plant species. However, phylogenetic relationships of Amazonian species within *Miconia* sect. *Discolor* are still unclear due to poor sampling [13]. These species mostly display lepidote hairs on leaves and scorpiod inflorescences, composing the informal Chrysophylla group [13]. As these phylogenetic relationships remain unclear, inference on natural selection within *Miconia* sect. *Discolor* are hampered.

The first objective of this project is inferring phylogenetic relationships and revising species diversity within the Chrysophylla group of *Miconia* sect. *Discolor*. The second objective is inferring natural selection over lineages within *Miconia* sect. *Discolor* that occupy different climatic niches.

Material and Methods

For the phylogenetic and revisionary studies of the Chrysophylla group, I will sample specimens that display the putative diagnostic features of the group (lepidote hairs on leaves and scorpiod inflorescences). Sampling will include herbaria and fieldwork. I will visit the following herbaria: BHCB, BM, BR, CEPEC, FLOR, G, GH, HB, HUEFS, IAN, INPA, K, M, MBM, MBML, MG, NY, P, RB, SPF, UEC, UPCB, US, and W[15]. Fieldwork will focus on national and local reserves within the Amazonia rainforest. In field, I will sample leaf tissue from specimens in silica-gel for DNA extraction[16].

In order to infer phylogenetic hypotheses, I will amplify five molecular markers that have shown adequate polymorphism within *Miconia* sect. *Discolor*: the nuclear ETS and ITS, and the plastidial accD-psaL, atpF-atpH, and psbK-psbL[13]. I will choose best-fit substitution models for each marker with jModelTest [17], and I will infer phylogenetic hypothesis using both Bayesian inference and maximum likelihood criteria [18].

In order to conduct a taxonomic revision, I will describe specimens' morphology based on standardized terminology [19]. Specimens will be identified by comparison to species protologues available at the literature [20,21] and to type specimens available at herbaria. If specimens do not fit any described species, I will consider describing new species.

For the evolutionary study on selection in different climatic niches, I will collect geographic occurrences and trait measurements for each species within *Miconia* sect. *Discolor* (ca. 60 spp). Geographic occurrences will be extracted from SpeciesLink and PBI-Miconiae platforms. Traits will be measured on vouchers from the above-cited herbaria, with at least 20 specimens per species. Based on standardized protocols[22], I will measure five plant traits that have shown correlation with climatic variables: plant height, leaf area, leaf specific area, stomata density, and seed size[3].

In order to infer climatic niches for each species, I will apply MaxEnt[23] modeling to climatic measures retrieved from the superimposition of geographic occurrences and WorldClim[24] climatic rasters. To assess if species occupy different niches or not, I will apply a grid-based equivalency test to MaxEnt models [25]. Species displaying non-significant differences in the equivalency test will be classified into a same climatic niche category.

In order to infer selection over lineages occupying different climatic niches, I will apply phylogenetic comparative methods to the five traits measured on specimens. Comparative methods will use models of phenotypic evolution over a random sample of phylogenetic trees retrieved from previous Bayesian inference. Brownian motion (BM) models will represent neutral evolution[26], while Ornstein–Uhlenbeck process (OU) models will represent evolution under selection[27]. Based Akaike criterion (AIC), I will choose the best-fit model. If OU models are the best fit, selection may have taken place over plant traits, so I will compare estimates of phenotypic optima (θ) and selection intensity (α) along lineages. If climatic niches have driven selection in *Miconia* sect. *Discolor*, estimates of θ and α will significantly differ among lineages occupying different climatic niche categories.

Predicted outputs: a systematic study to be published at *Botanical Journal of the Linnean Society*; an evolutionary study to be published at *Proceedings of the Royal Society B: Biological Sciences*; updates of *Miconia* database at Flora do Brazil 2020 (http://reflora.jbrj.gov.br/reflora); presentation of results at the Latin American Botanical Congress; scientific divulgation at UFABC outreach project "*UFABC para todos*"

Required budget: $820, of which: $160 - flying ticket from São Paulo to Manaus; $110 fieldwork at Ducke's National Forest Reserve (5 days); $500 - flying ticket from Manaus to Belém; $35 - visit to Emílio Goeldi Museum's herbarium (3 days); $15 - DNA/specimen preservation and shipment.

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