Unraveling the stages of ant diversification in Madagascar

Evan Economo*[1], Nicholas Friedman[1], Francisco Hita Garcia[1], Georg Fischer[1], Bonnie Blaimer[2], Julian Katzke[1], Evropi Toulkeridou[1], Adam Khalife[1,3], Douglas Booher[4,5], Alexander Mikheyev[1,6], and Brian Fisher[7]

[1]Okinawa Institute of Science and Technology (OIST) – 1919-1 Tancha Onna-son Okinawa, 904-0495, Japan

[2]North Carolina State University (NCSU) – Raleigh, NC 27695, United States

[3]Université Pierre et Marie Curie – Université Pierre et Marie Curie - Paris 6 – 4 Place Jussieu, 75005 Paris, France

[4]University of Illinois Urbana-Champaign – Champaign, IL, United States

[5]Field Museum of Natural History (FMNH) – 1400 S Lake Shore Dr, Chicago, IL 60605, United States

[6]Australian National University (ANU) – The Australian National University Canberra ACT 0200 Australia, Australia

[7]California Academy of Sciences – 55 Music Concourse Dr, San Francisco, CA 94118, United States

Abstract

Evolutionary radiation typically involves the divergence of lineages across geographic, ecological, and phenotypic spaces, but diversification may not happen along these dimensions simultaneously. Indeed, both theory and empirical studies have suggested that radiation may occur in stages, for example with diversification first occurring along climatic gradients and later along body size (or vice versa). This may reflect evolutionary "paths of least resistance"; the relative ease in which species can cross dispersal barriers, evolve across morphospace, and adapt to different climates. However, it is still unclear whether radiations are generally staged, and, if they are, whether the ordering of the stages is general across taxa or highly idiosyncratic. Here, we assemble an unprecedented dataset for ants encompassing the taxonomic, geographic, phylogenomic, and phenomic dimensions of ant biodiversity in Madagascar to analyze the dynamics of diversification across five major ant radiations on the island (total _˜ 500 species). As an isolated mini-continent, Madagascar is both a model system for comparative analysis of diversification and also a critically important region for conservation. Building upon 25 years of intensive ant biodiversity inventory across Madagascar, we analyze the distribution of species across the main geographic regions of the island, across ecoclimatic gradients, and in 3D morphospace as quantified by X-ray microcomputed tomography and 3D geometric morphometrics. Phylogenomic reconstructions show that a small handful of colonizing lineages seeded massive radiations in the five focal genera after colonization. In general, we found evidence of staging in each group, as radiation proceeded along certain dimensions early and others later, rather than a synchronous accumulation of diversity in all dimensions. However, the ordering of these stages varied considerably among taxa, with morphology diversifying first followed later by climatic tolerance in some taxa, while in others the reverse was true. These differences were partially understandable, for

*Speaker

example one genus lacks flying queens and showed much more geographic structure to the radiation, but in many cases are enigmatic. These results shed light on the dynamics of adaptive radiation in this biodiversity hotspot, while highlighting questions about why the adaptive potential of different lineages varies so considerably across dimensions of biodiversity.

Keywords: adaptive radiation, ants, Madagascar, diversification, biogeography, morphology