Phylogenetic patterns of extinction risk: the need for critical application of appropriate datasets

Roy E. Gereau[1*], Neil D. Burgess[2,3], Jon Fjeldså[4], Jaclyn Hall[5], Andreas Hemp[6], Alistair S. Jump[7], Asukile R. Kajuni[8], Robert A. Marchant[9], Andrew R. Marshall[10,11], Philip J. Platts[9], Charlotte M. Taylor[1], Flora I. Tibazarwa[12]

[1]Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299, U.S.A.

[2]Conservation Science Group, Zoology Department, University of Cambridge, Cambridge, CB2 3EJ, UK

[3]WWF-US Conservation Science Program, 1250 24th Street NW, Washington DC 20037, U.S.A.

[4]Center for Macroecology, Evolution and Climate, Natural History Museum of Denmark, University of Copenhagen, DENMARK

[5]Department of Geography, University of Florida, 3141 Turlington Hall, Gainesville, FL 32611-7315, U.S.A.

[6]Department of Plant Systematics, University of Bayreuth, Universitaetsstr. 30-31, 95440 Bayreuth, GERMANY

[7]Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

[8]WWF Tanzania Country Office, Plot 350, Regent Estate Mikocheni, P.O. Box 63117, Dar es Salaam, TANZANIA

[9]York Institute for Tropical Ecosystems, Environment Department, University of York, York, YO10 5DD, UK

[10]Centre for Integration of Research, Conservation and Learning (CIRCLE), Environment Department, University of York, York, YO10 5DD, UK

[11]Flamingo Land Ltd., North Yorkshire, YO17 6UX, UK

[12]Tanzania Commission for Science and Technology, P.O. Box 4302, Dar es Salaam, TANZANIA

[*]Correspondence: telephone +1 (314) 577-9574; e-mail roy.gereau@mobot.org

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Abstract

In order to conduct a replicable analysis of the possible phylogenetic patterns of extinction risk, one must first formulate a clear set of definitions of ecosystem boundaries and risk categories. Subsequently, a robust and internally consistent dataset that includes all the available information on species distributions and risk assessments must be assembled. Here, we review the dataset and methodology of a recent paper focused on phylogenetic patterns of plant extinction risk in the Eastern Arc Mountains of Kenya and Tanzania and point out some of the limitations of inferring such patterns from inadequate and biased data. We show that bias in the dataset is probably responsible for the conclusion that Vulnerable species are more closely related than expected by chance, and provide guidelines for the construction of an appropriate dataset for such an analysis.

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Introduction

Natural habitats are changing at a rate unprecedented in human history, as a result of both direct and indirect human disturbance. It is thus essential to understand the extinction risk facing species in ecosystems worldwide (Butchart et al., 2010). Yessoufou, Daru & Davies (2012) present an approach that aims to elucidate phylogenetic factors that have a role in determining the extinction risk of plant species in diverse tropical ecosystems, and suggest that their results may be used to guide conservation management. We are concerned, however, that their study suffers from several methodological flaws that undermine the reliability of their conclusions and have the potential to misdirect conservation efforts. Our principal criticisms of the paper are: 1) inadequate knowledge of the study area, its flora, and relevant literature; 2) lack of transparent or repeatable methods for data selection, compounded by inadequate sample size; and 3) compilation and analysis of an inconsistent dataset containing non-equivalent Red List assessments performed under different criteria and at different times.

Characterization and delimitation of study area

The study by Yessoufou, Daru & Davies (2012) focuses on selected plants of Tanzania, with particular reference to part of the Eastern Arc Mountains of Kenya and Tanzania. Despite the authors' claim to have made "a thorough literature survey", they cite no recent literature characterizing the area's ecosystems and vegetation (e.g. Critical Ecosystem Partnership Fund, 2003; Conservation International, 2008) or detailing its flora and plant endemism (e.g. Gereau, Taylor & Luke, 2006), conservation assessments and priorities (e.g. Newmark, 2002; Doggart et al., 2006; Gereau et al., 2009; Platts et al., 2010; Ahrends et al., 2011), elevational distribution of extinction risk (e.g. Hall et al., 2009), ecological and environmental history (e.g. Finch, Leng & Marchant, 2009; Finch & Marchant, 2011), or physiographic delimitation (e.g. Platts et al., 2011). This lack of adequate context is reflected in the authors' characterization of the Eastern Arc Mountains as "woefully-understudied", and crucially undermines their ability to interpret their findings accurately and objectively.

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Yessoufou, Daru & Davies (2012) present a general description of the physical and biological properties of the Eastern Arc Mountains, yet they do not provide a rigorous delimitation of the study area's geographic boundaries, altitudinal limits, or other parameters (cf. Platts et al., 2011). Thus the criteria for selection of their list of 230 Eastern Arc plant species with data on threat status (presented in their Table S2) are unclear, so that the list cannot be tested nor a comparable list compiled from other data or by other researchers. Furthermore, the authors leave out of their analysis the flora of an important part of the Eastern Arc, the Taita Hills of Kenya, although they include the Taita Hills in their description of the study area. The entire Eastern Arc has long been identified as a single area for conservation and phytogeographic analysis (Lovett, 1990, 1993; Burgess et al., 2007). Thus the inclusion of the entire area is important to achieve the stated goals of the study, and at a minimum the exclusion of the Taita Hills from the study should be justified.

Limitations and bias of the dataset

For their analysis of conservation status and phylogeny, the authors downloaded assessment details from the IUCN Red List website (www.iucnredlist.org) for the 581 Tanzanian flowering plant species that had been posted as of May 2012. By the authors' own statement, this constitutes about 5% of the total country flora. This sample is not adequate or representative, either phylogenetically or phytogeographically, to address patterns of extinction risk across any regional flora. For these 581 species, 249 assessments were performed between 1998 and 2000 using the IUCN Categories and Criteria version 2.3 (IUCN, 1994), and 332 were performed between 2003 and 2011 using the Categories and Criteria version 3.1 (IUCN, 2001). Because of marked methodological differences between versions 2.3 and 3.1, these two sets of assessments are not comparable and should at the least be analyzed separately. Indeed, it is doubtful that assessments using version 2.3 should be analyzed at all before reassessment under version 3.1 (http://www.iucnredlist.org/documents/RL_Criteria_1994_versus_2001.pdf).

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Although the authors examine the possibility of taxonomic bias in the assessed species, the bias in species selection for Red List assessment is not primarily taxonomic. Species are selected for assessment primarily due to other factors including rarity, restricted distribution, extreme habitat specialization, and human exploitation (Gereau et al., 2009). This creates an *a priori* bias toward inclusion on the Red List in the threatened categories, independent of taxonomy. Assessments performed under Red List Criteria version 2.3 were also strongly biased toward woody species, with almost no herbaceous taxa assessed during this period, even though herbaceous species comprise ca. 60-70% of the East African flora and the Eastern Arc Mountains consist not only of forests but also significant areas of grassland, woodland, and other habitats with a high diversity of herbaceous species. Both East Africa as a whole and the Eastern Arc in particular have given rise to major species radiations of herbaceous families and genera of significant management concern (e.g. Orchidaceae [orchids], 207 species in Eastern Arc; *Impatiens* ['Busy Lizzie'], 42 species; *Saintpaulia* ['African Violet'], 8 species with 9 mostly very localized subspecies, i.e. all species in the genus, with 7 species and 8 subspecies endemic to the Eastern Arc), which are significant for understanding the extinction dynamics of this flora, yet none of these are represented in the analysis.

A principal conclusion of Yessoufou, Daru & Davies (2012) is that "Vulnerable species are more closely related than expected by chance, whereas endangered and critically endangered species are not significantly clustered on the phylogeny." However, the assessments performed under Red List Criteria version 2.3 were strongly operationally biased toward the Vulnerable category. In a series of seven Red List workshops conducted between 2006 and 2013, the Eastern African Plant Red List Authority (EAPRLA) has reassessed many of these species under version 3.1 and has moved many of them into higher threat categories or downgraded them to Near Threatened or Least Concern. The results of these Red List workshops are currently being processed by the IUCN and are expected to be accessible on the Red List website (www.iucnredlist.org) before the end of 2013 (W.R.Q. Luke pers. comm., 2013).

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Improvement of the dataset

Using the mountain bloc boundaries as delimited by Platts et al. (2011) and a comprehensive checklist of the Eastern Arc flora downloaded from www.tropicos.org, we find that 1142 Eastern Arc plant taxa (949 species, 193 subspecies and varieties) have information on threat status (www.iucnredlist.org, accessed April 2013; W.R.Q. Luke pers. comm., 2013). Of these, 1031 taxa have been assessed under Red List criteria version 3.1. Of the 111 taxa assessed under version 2.3 and still pending reassessment, 92 (82.9%) are in the Vulnerable category, demonstrating the above-described bias toward this category in early assessments. In contrast, of the 1031 taxa assessed under version 3.1, almost half (486 taxa) are in non-threatened categories and, of those in threatened categories, the distribution across threat categories is relatively balanced (14% CR, 45% EN, 41% VU). We conclude that any statistical groupings of families based on the admixture of assessments performed under versions 2.3 and 3.1 are unlikely to have phylogenetic relevance.

Conclusion

In conclusion, we emphasize that the analytical methods suggested by Yessoufou, Daru & Davies (2012) may potentially have significant value for analysis of phylogenetic patterns of extinction risk, in the Eastern Arc Mountains and elsewhere, but that this can only be realized through critical application of appropriate datasets, underpinned by a thorough review of current knowledge of a region and its flora.

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