Peer Community In Ecology

Elevation, environmental heterogeneity and the island speciation engine

Pierre Gauzere *based on peer reviews by 2 anonymous reviewers*

Baptiste Brée, Thomas J. Matthews, José María Fernandez-Palacios, Christian Paroissin, Kostas A. Triantis, Robert J. Whittaker, François Rigal (2024) The biogeography of evolutionary radiations on oceanic archipelagos. bioRxiv, ver. 2, peer-reviewed and recommended by Peer Community in Ecology.
https://doi.org/10.1101/2024.10.07.616413

Submitted: 23 October 2024, Recommended: 18 July 2025

Cite this recommendation as:
Gauzere, P. (2025) Elevation, environmental heterogeneity and the island speciation engine. *Peer Community in Ecology*, 100764. https://doi.org/10.24072/pci.ecology.100764

Published: 18 July 2025

Island biogeography has long inspired theory, yet quantitative tests of how within-radiation diversity scales with island properties remain scarce. Brée et al. (2024) assembled a nicely curated dataset of 95 evolutionary radiations (ROAs) distributed across four classic volcanic archipelagos—Hawaii, the Canary Islands, the Galápagos and Fiji—encompassing vascular plants, invertebrates and vertebrates. By pairing island-specific species counts for each radiation with a common suite of geo-environmental descriptors, the authors ask two deceptively simple questions: (i) which island traits best explain richness patterns inside radiations, and (ii) does the strength of those effects vary among archipelagos and broad taxonomic groupings?

Across the whole dataset, maximum elevation emerges as the most frequent and robust positive predictor of intra-radiation richness. I find this result persuasive because it echoes broader evidence that steep environmental gradients boost speciation by multiplying ecological opportunities (Barajas-Barbosa et al. 2020; Steinbauer et al. 2016).

Although elevation dominates overall, the strength and sign of other drivers vary with geological context. In Hawaii, richness tends to rise with island area and with a measure of topographic complexity, whereas in the Canaries a hump-shaped relationship with island age combines with a negative effect of inter-island isolation; Fiji shows a similarly strong age signal but little isolation effect, and the Galápagos yield no single dominant factor. Such contrasts fit neatly within the general dynamic model oceanic island biogeography, which predicts that the diversification process shifts as islands move through their ontogeny (Whittaker et al. 2008).

A notable virtue of the study is its resolution at the level of clades rather than whole biotas. Treating each radiation as an independent replicate avoids the taxonomic pooling that can obscure lineage-specific responses. For example, Brée et al. (2024) show that elevation effects are stronger for plant radiations than for invertebrates

in the Canaries but not in Hawaii, demonstrating an interaction between intrinsic life-history traits and extrinsic environment.
The authors candidly discuss limits of coverage—Hawaii and the Canaries still dominate island-radiation research and explain why formal classification of speciation modes was premature given current phylogenetic evidence. Time since colonisation, although difficult to estimate consistently, could further refine the observed age–diversity relationships. Even so, the present analysis already sets a benchmark for clade-level biogeographic modelling.

In sum, I am pleased to recommend this pre-print as it demonstrates convincingly that vertical relief—and the ecological heterogeneity it proxies—serves as the principal engine of speciation on young oceanic islands, while the influence of area, age and isolation is contingent on geological history and lineage traits. Their synthesis advances island biogeography by moving beyond the classical focus on total species counts to illuminate the environmental controls on diversification within lineages. This work will interest researchers in macroevolution, community ecology and conservation, and it supplies a rich openly accessible dataset for future comparative work.

The data editor's report can be found below:

Editor: Matthias Grenié

1. Data

Data and metadata must be archived and adhere to FAIR guiding principles

[x] Data are in a public repository

[x] Data repository has a persistent identifier (e.g., a DOI)

[x] Data are cited in the manuscript (in data availability statement or similar, as well as in the Literature Cited)

[x] Data repository has a license

[x] All necessary data files are present in the repository

[x] All raw data present

If not:

[ ] Information on where raw data are located - (NOT APPLICABLE)

[ ] Information about how to access the raw data - (NOT APPLICABLE)

[ ] Sufficient information about database version/filtering/processing/exclusion criteria - (NOT APPLICABLE)

[x] All processed data present

[x] Data are contained in an interoperable format

[x] Tabular data - csv, tsv

[ ] Photos - (NOT APPLICABLE)

[ ] Videos - (NOT APPLICABLE)

[x] Metadata present (including README file)

[x] Metadata adequate (including README file)

Archived data corresponds with the data reported in the manuscript

[x] Variables used in analysis present in the data

[x] The structure of the data presented matches the manuscript (e.g., it is the right size)

2. Code

Code and metadata must be archived and adhere to FAIR guiding principles

[x] Code has a repository

[x] Code repository has a DOI

[x] Code is cited in manuscript

[x] Code repository has a license
[x] Code files are present in the repository
[x] Code is contained in an interoperable format
[x] Metadata present (README file and annotations in code)
[x] Metadata adequate

Archived code matches the manuscript
|x] Code is present for all analyses in the manuscript, along with code used to produce figures/tables where appropriate

Archived code runs with the archived data
[x] Runs without errors

3. Computational reproducibility
Results can be computationally reproduced by running the archived code
[x] Numeric results (in table or text)
[x] Figures

———–

Comments from the data editor:
Thank you for sharing your data and code openly!
All of the analyses ran fine on my machine without a bug and the last minor details have now been fixed.

References:

Baptiste Brée, Thomas J. Matthews, José María Fernandez-Palacios, Christian Paroissin, Kostas A. Triantis, Robert J. Whittaker, François Rigal (2024) The biogeography of evolutionary radiations on oceanic archipelagos. bioRxiv, ver.2 peer-reviewed and recommended by PCI Ecology https://doi.org/10.1101/2024.10.07.616413

Barajas-Barbosa, M. P., Weigelt, P., Borregaard, M. K., Keppel, G., & Kreft, H. (2020). Environmental heterogeneity dynamics drive plant diversity on oceanic islands. Journal of Biogeography, 47(10), 2248–2260. https://doi.org/10.1111/jbi.13925

Steinbauer, M. J., Field, R., Grytnes, J.-A., Trigas, P., Ah-Peng, C., Attorre, F., Birks, H. J. B., Borges, P. A. V., Cardoso, P., Chou, C.-H., De Sanctis, M., de Sequeira, M. M., Duarte, M. C., Elias, R. B., Fernández-Palacios, J. M., Gabriel, R., Gereau, R. E., Gillespie, R. G., Greimler, J., … Beierkuhnlein, C. (2016). Topography-driven isolation, speciation and a global increase of endemism with elevation. Global Ecology and Biogeography: A Journal of Macroecology, 25(9), 1097–1107. https://doi.org/10.1111/geb.12469

Whittaker, R. J., Triantis, K. A., & Ladle, R. J. (2008). A general dynamic theory of oceanic island biogeography. Journal of Biogeography, 35(6), 977–994. https://doi.org/10.1111/j.1365-2699.2008.01892.x

Reviews

Evaluation round #2

Reviewed by anonymous reviewer 2, 19 June 2025

Thank you for considering my review comments and making additions/changes to the manuscript. I have no further recommendations.

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2024.10.07.616413
Version of the preprint: 1

Authors' reply, 26 May 2025

Download author's reply
Download tracked changes file

Decision by Pierre Gauzere, posted 22 April 2025, validated 22 April 2025

Dear authors,

First, sorry for the long time it took to get a feedback. It was really hard to find reviewers and once I found them it took a long time to get the last review.

After thorough evaluation of the manuscript and its reviews, I recommend that the manuscript be revised. The study has the potential to make a significant contribution to the literature on island biogeography, provided the authors address the concerns regarding representativeness, interpretation, and clarity.

I think that the manuscript offers substantial value to the field of island biogeography and macroecology. Both reviewers appreciated the overall clarity, conceptual grounding, and relevance of your findings. Nevertheless, several concerns and suggestions raised during the review process must be addressed before the manuscript can be recommended.

- Overrepresentation of a few archipelagos: One of the reviewers noted the data are drawn from limited number of archipelagos. While this reflects data availability and the filtering criteria employed, it substantially constrains the generality of the conclusions. The authors should further acknowledge and elaborate on this potential strong limitation of the breath of their results. Consideration of how this taxonomic and geographic skew may bias the identified relationships would strengthen the manuscript.

- Speciation mechanisms and interpretation of radiations: One of the reviewer rightly observes that the mode of speciation is not always relevant when assessing richness within radiations. The manuscript currently touches on this in a somewhat cautious manner. Expanding this discussion — particularly the diversity of speciation modes across taxa and how this may influence patterns of Island SROA — would enrich the interpretation and contextualization of the results.

- Additional clarification on intra- vs. inter-island speciation dynamics: a reviewer raised a pertinent point about how area and elevation may influence not just within-island speciation, but also inter-island colonization and reduced extinction. While the manuscript acknowledges this to some extent, a clearer separation or discussion of these mechanisms — perhaps acknowledging their taxonomic specificity — would be helpful.

- Impact of time since colonization: Although the current models include island age and SIE proportion, the idea that the variation in richness across lineages may be influenced by time since colonization (rather than

simply geological island age) is compelling. If relevant data are lacking, a short paragraph acknowledging this issue and its implications for interpreting radiation size would be appropriate.

- Improving the clarity of the methods: while the methods are likely replicable, some sections are difficult to follow for non-specialists. It would be beneficial to simplify or summarize key steps in the main text, while referring readers to the Appendices for details (e.g., how isolation indices were selected).

I look forward to receiving a revised version of the manuscript that takes into account the thoughtful feedback provided by the reviewers. Sorry again for the long delkay in processing the paper !

Reviewed by anonymous reviewer 1, 04 December 2024

Summary

Breé et al. conducted a comprehensive literature survey on radiations in oceanic archipelagos, examining the relationship between radiation diversity and ecological attributes. Their analyses revealed that elevation is a key driver of species richness in radiations, while also highlighting variation in the influence of geo-environmental factors on diversification dynamics.

Overview

This manuscript is well-written, presenting clear hypotheses and offering a well-executed piece of work. While I am not an ecologist (and may therefore be somehow mistaken in my assessment), it seems that many ideas and hypotheses in the island literature have historically been somewhat speculative—rooted in decades of naturalist observation but lacking direct testing. This study, however, provides a valuable contribution by rigorously testing specific ecological hypotheses. In this regard, I believe it will be an important and impactful paper for researchers in island biology.

I have only a single major comment (which is medium'ish in reality):

On line 433 it states that there is no indication of speciation for most radiations. While I agree this is true, I think the type of speciation is irrelavant for radiations. Radiations comprise a mix of ecological vs non-ecological speciation (e.g. allopatry), and not necessarily only ecological speciation as I can think of cases where differences accumulate in allopatry and upon secondary contact character displacement occurs.

Title and abstract

Does the title clearly reflect the content of the article? **Yes!**

Does the abstract present the main findings of the study? **Yes!**

Are the research questions/hypotheses/predictions clearly presented? **Yes!**

Does the introduction build on relevant research in the field? **Yes!**

Materials and methods

Are the methods and analyses sufficiently detailed to allow replication by other researchers? **Yes**, I believe so. I am not an ecologist and some of the methods are unfamiliar to me so it was hard for me to follow every detail, but I believe so.

Are the methods and statistical analyses appropriate and well described? **Yes**, I believe so.

Results

In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? **Not relevant.**

Are the results described and interpreted correctly? **Yes**.

Discussion

Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? **Yes**

Are the conclusions adequately supported by the results (without overstating the implications of the findings)? **Yes**.

Reviewed by anonymous reviewer 2, 07 April 2025

The biogeography of evolutionary radiations on oceanic archipelagos

What governs species diversity on oceanic islands? That questions has been approached from many angles over the years, and this manuscript aims to add to the discussion. After using a set of filtering criteria, radiations on oceanic archipelagos are analyzed in light of a set of variables (e.g., elevation, age, etc). The main finding, that elevation is the key factor explaining diversity levels, is not surprising based on theory and empirical studies. But the authors appropriately acknowedge this as an expected result. I have a couple of general thoughts or questions below.

The filtering process results in three small, remote archipealgos comprising 85% of the ROAs under consideration. Granted, these archipelagos are feature disproportionately in our understanding of island evolution and evolution in general. But for me, continuing the focus on these archipelagos dimishes the potential impact of the study. The "limitations" section mentions some possible biases due to the filtering process, but this extreme reliance on so few archipelagos seems like it merits discussion here.

Throughout the paper, island area, and elevation to a lesser extent, are emphasized as factors influencing diversity via intra-island speciation (e.g., lines 71-74). This is certainly a factor, but the greater diversity predicted by speciea-area relationships should also have influences on reduced extinction and accumulation of species via inter-island speciation. Although the intra- vs. inter-island speciation importance is likely to be highly lineage dependent (vertebrate evolutionary biologist here).

The extent of variation across lineages and archipelagos was interesting. The study accounted for island age, but I wonder if some of the variability across lineages could be correlated with time since arrival. This is likely beyond the scope of the study or data collected, but might be worth mentioning.

Does the title clearly reflect the content of the article? [X] Yes, [ ] No (please explain), [ ] I don't know

Does the abstract present the main findings of the study? [X] Yes, [ ] No (please explain), [ ] I don't know

Are the research questions/hypotheses/predictions clearly presented? [X] Yes, [ ] No (please explain), [ ] I don't know

Does the introduction build on relevant research in the field? [X] Yes, [ ] No (please explain), [ ] I don't know

Are the methods and analyses sufficiently detailed to allow replication by other researchers? [X] Yes, [ ] No (please explain), [ ] I don't know

Are the methods and statistical analyses appropriate and well described? [X] Yes, [ ] No (please explain), [ ] I don't know

In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? [ ] Yes, [ ] No (please explain), [ ] I don't know

Are the results described and interpreted correctly? [X] Yes, [ ] No (please explain), [ ] I don't know

Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? [ ] Yes, [X] No (please explain), [ ] I don't know; See above - just some minor suggestions about the focus on so few archipelagos.Are the conclusions adequately supported by the results (without overstating the implications of the findings)? [X] Yes, [ ] No (please explain), [ ] I don't know