

Author's response

Associate Editor

Dear authors

Thanks a lot revising the manuscript that carefully and please apologize the time until the manuscript was reviewed. Both reviewers noted that the manuscript improved considerably, but their overall judgement differed considerably. While reviewer #1 finds it a valuable contribution and suggested minor revisions with a tendency towards major, reviewer #2 rejected the manuscript due to the lack of biogeochemical data. I also find the manuscript close to the “least publishable unit” for a biogeochemical journal, but above the threshold. Therefore, ask you for major revisions following the comments of reviewer#1.

Reply: Thank you very much for your feedback. We highly appreciate your decision to keep our manuscript in the submission system. We carefully revised the manuscript according to the comments and suggestions of reviewer #1.

Reviewer #1

I think the authors have made considerable improvements to the manuscript, but I think the manuscript requires additional effort to turn the changes into a cohesive story. Especially the discussion requires a restructure and some re-writing to accommodate the new ideas that have been implemented based on the previous round of reviewer comments. I also have a minor restructure suggestion in the introduction that should be easily addressed and feel that the main aim of the study should be better formulated. These points, and some additional textual suggestions, are specified below.

Reply: Thank you very much for your valuable suggestions and comments on the manuscript that we used as guidance to improve our work. Accordingly, the introduction and discussion were adjusted, and further textual changes were implemented.

L.51: “such as e.g.”, remove either such as, or e.g

Reply: Done.

L.81: “A higher nutrient availability...”. This sentence feels disconnected to the rest of the paragraph, which is about the age aspect of phonolites vs basalt. I think you can move this statement to the next paragraph, as the nutrient aspect of phonolites is further explored there.

Reply: We started a new paragraph at this point, following your suggestion.

L.115-117: “We aim...La Palma”; I would rewrite and move this paragraph. I think the aim is formulated poorly considering the hypotheses that are formulated later and the data that is

collected (i.e. plant performance is not mentioned and you don't need to measure plant traits to assess species richness and abundance). This paragraph also makes me question the function of the next paragraph, and how this related to the aim presented here. Instead, I think the next paragraph (starting at L.119: "La Palma hosts 159 vascular plant species") connects well to the previous paragraph (ending at L.113: "species specialised to phonolitic rocks"), and I would move the general aim to just before the formulation of the hypotheses.

Reply: Thank you very much. We moved this paragraph from the previous position to just before the hypotheses. Now the two paragraphs before are better connected, and we agree that this change increases the quality of the introduction.

L.139: Add "We expect"

Reply: Done.

L.229: remove one "by"

Reply: Done.

L.230: "reproductive fitness"; remove "reproductive" or change to "performance"

Reply: We changed it to "performance".

L.237: "species numbers on phonolites"; add "or both"

Reply: We changed it accordingly.

L.237: "studies, which..."; change to "studies that"

Reply: We changed the wording according to your suggestion.

L.238: "Reasons..."; only one reason is presented.

Reply: We changed your sentence and rephrased it to: "Unrealised niches due to unsaturated evolutionary dynamics in this young and isolated system could be an explanation."

L.242-244: "Characteristics of rocks include, ... (as a proxy for rock surface temperature). " I think I would remove these sentences. I don't like how they create an expectation that isn't met in point 3 (while I certainly think it is a valuable discussion point), and they don't capture the paragraph after these 3 points that talks about extinction debt, which is tied to substrate age. Instead, I would encourage the authors to focus on writing 3-4 strong self-standing paragraphs that convey a single message or explain a single result and don't need an introduction like this.

Reply: We deleted these sentences accordingly. We also deleted the numbering of the following paragraphs to avoid listing and to give these points an individual message. Furthermore, we restructured and partly rewrote the following paragraphs to strengthen their message, including your detailed suggestions below.

L.248: “nutrient-rich as it has traditionally been...”; the grounding up of these rocks is not a cause of its nutrient richness, but rather the other way around. Change to: “nutrient-rich, and therefore has traditionally been...”

Reply: Thank you for this attentive observation. We changed these sentences substantially due to the restructuring of the whole paragraph. However, we made sure that the content of the according sentence is logical: “Therefore, ground phonolite rock powder has traditionally been used as an inorganic fertilizer (von Wilpert & Lukes, 1998; Ramos et al., 2006; Schoen et al., 2016).”

L.252-254: “Since ground ... rock characteristic.” Again, the grounding up of these rocks is not a cause of its nutrient richness, but rather the other way around. Please rephrase.

Reply: Thank you. Due to the restructuring of this paragraph, we deleted this sentence.

L247-261: The argumentation of this paragraph is not convincing and in places is even incorrect, warranting considerable rewriting, especially given the journal being a biochemical one. The main message that the authors should try to convey is that phonolites and basalts have different chemical compositions, leading to differences in their nutrient availability, which can explain the observed increase in plant performance on phonolitic rocks.

Reply: We agree. This paragraph has been substantially rephrased according to your suggestions:

“The rock types phonolite and basalt differ in their chemical composition resulting in different nutrient availability, which explains our observation of increased plant performance on phonolites. Phonolites consist of the potassium-rich nepheline, which dissolves much faster than other potassium sources (Manning, 2010). Various studies indicate that phonolites and the related nepheline syenite contain a higher proportion of potassium than basalt (Manning, 2010; Roqueto do Reis, 2021). Therefore, ground phonolite rock powder has traditionally been used as an inorganic fertilizer (von Wilpert & Lukes, 1998; Ramos et al., 2006; Schoen et al., 2016). Basaltic rock powder has also been used as fertilizer but is considered a less important source of potassium than phonolite (Manning 2010). The usage of ground basalt as fertilizer can also be explained by unclear assignments (potassium-rich trachyte is often assigned to basalt, see Maning (2010)). In addition to geochemical differences, the duration of rock weathering is a decisive factor in providing nutrients. The phonolitic outcrops in Southern La Palma are substantially older than the surrounding basalt, which stems from very young volcanic eruptions (Carracedo et al., 1999). The youngest nearby eruption of the Teneguía volcano took place only 50 years ago, in 1971.”

L.265: “studies...” only 1 study is provided.

Reply: Thank you, this part has been deleted as we restructured large parts of the discussion.

L.270: “Consequently ... unsaturated niches.” In the current wording, this refers back to the phonolitic rocks, while these are the old rock type and I would thus expect to have an extinction debt due to recent reductions in habitat area, not unsaturated niches, which I would expect in the surrounding, much younger, basalt habitats. Also see my more elaborate explanation in the previous round of reviewer comments.

Reply: We agree that the previous notion was unclear. We deleted the previous sentence, shortened this paragraph and rephrased it from here on:

“In consequence, the species pool in the surrounding basaltic matrix of these rocks is poor. Under the arid conditions of southern La Palma, only very few early successional species establish on these young basaltic outcrops with not more than initial soil formation (Irl et al. 2019). The few rocky outcrops of phonolite are embedded in this species poor matrix of young basalt. We observed partly buried phonolites on which the survival of plants or seedlings during volcanic events was improbable (Garantje et al., 1998). Carracedo et al. (1999) showed that the last phonolite formation occurred in 1585, while basaltic eruptions continue until modern times (Pankhurst et al. 2021). 19 plant species, including *Cheirolophus junonianus*, can solely be encountered on phonolitic rocks (Irl et al., 2015, Muer et al., 2016). This confirms that habitat diversity on islands contributes to their total species richness (Hortal et al., 2009).”

In addition, we added a reference to support the statement of a species poor pool of species in early successional stages on these volcanic substrates.

Irl, S. D. H., Schweiger, A., Hoffmann, S., Beierkuhnlein, H., Pickel, T., and Jentsch, A.: Spatiotemporal dynamics of plant diversity and endemism during primary succession on an oceanic volcanic island. *J. Veg. Sci.*, 30(4), 587-598, 2019.

Additionally, we included a sentence about the extinction debt that might explain higher species numbers on phonolites compared to basalt earlier in the discussion (line number in revised manuscript: 244-246).

L.279-280: “Interestingly, ... rock type.” It is unclear to me what result this statement refers to.

Reply: This sentence was replaced by the paragraph mentioned above.

L.299: “While rock chemistry ... distinct vegetation.” Chemistry and age are brought forth as potential explanations, you do not provide data-driven evidence of a causation. As such please rephrase this sentence.

Reply: We rephrased this sentence the following way: “While a diversity of rocks with different chemical characteristics and at different ages supports species richness on volcanic islands, such rock characteristics do not necessarily contribute to higher percentages of endemic plants or compositional distinct vegetation on individual rocky outcrops.”

L.300: “*Cheirolophus junonianus* with its two varieties var. *junonianus* and var. *isoplexiphyllus* is confined to phonolites...” I still fail to see how specific mention of this particular species is conducive to answering the research questions. I see the value of mentioning it in the introduction as an example, but not here.

Reply: We followed your suggestion, and *Cheirolophus junonianus* is no longer mentioned in this line. The importance of this specific plant species was reduced in the entire discussion.

L.304: “the underlying cause.” of what?

Reply: We deleted this sentence entirely because the statement is not supported by data but is a subjective observation. This part of the discussion was shortened, and the message was formulated clearer:

"Thus, the differential geology of phonolites itself does not result in a specialized flora. Obviously, the small outcrops of phonolite on La Palma do not suffice to evolve and maintain a substantial set of endemic species, which contrasts with general assumptions that patterns caused by differing topography or discontinuous parent material can be explained by island biogeographic theory (e.g., Kruckerberg 1991)."

L.299-315: The main message of this paragraph is the potential of extinction debt on phonolitic rocks, but I think the authors should drop the one species that occurs only on phonolitic rocks, and instead focus on the larger number of species that occur only on phonolitic rocks compared to the number of species that occur only on basaltic rocks. I also think this can be better tied to the age and geological history of the rock types, as well as the potential for unsaturated niches on basalts. Each of these elements is discussed separately, but I would recommend a restructure to bring at least the extinction debt and the unsaturated niches ideas together on one paragraph.

Reply: Thank you for this comment. We also restructured the paragraph considerably. It now focusses purely on endemic species. We moved the sentences about a possible extinction debt to the beginning of the discussion and discussed it with potential unsaturated niches (line number in revised manuscript: 244-246). As extinction debts do not solely apply to endemic species but to species in general, we argue that it fits better into the discussion about different species richness on phonolites and basalt. We hope to convince you that these changes help streamline the discussion and increase the quality of this manuscript.

As suggested, the emphasis of the paragraph is no longer on *Cheirolophus junonianus*, and we now discuss the entire pool of endemic species targeted in our investigation.

L.317-330: I fail to see how the main message of these two (very) short paragraphs relate to the aim of the study.

Reply: We deleted the two short paragraphs and instead extended the last paragraph that now contains a stronger reference to our aims. The last paragraph now reads:

"Despite the limited spatial extent of phonolites on La Palma they contribute to insular habitat heterogeneity that translates into increased species richness and abundance as well as higher plant performance. These phenomena are facilitated by the specific characteristics of phonolite rock, like high nutrient availability fortified by longer geological timeframes for erosion compared to basalt. We are not aware of other studies conducted in locations where phonolites can be encountered that explore their potential role as exceptional plant habitat islands, even though phonolites can be found all over the world (Garcia et al., 1986; Ackerman et al., 2015; Hagos et al., 2017). Therefore, further investigation is needed to investigate whether the patterns encountered on La Palma may also be found on comparable phonolitic rocks in other areas of the world. Their benefits for biodiversity found in this study need to be recognized and valued. Especially for isolated areas such as islands, phonolites can contribute to small-scale biodiversity hotspots and our findings suggest that they should be conserved."