CORRESPONDENCE

Comment on 'Island biogeography: patterns of marine shallow-water organisms' by Hachich *et al.*, *Journal of Biogeography* (2015)

ABSTRACT

In a recent article, Hachich *et al.* (2015, *Journal of Biogeography*, **42**, 1871–1882) studied the large-scale biogeographical patterns of the species–area, species–island age and species–isolation relationships associated with marine shallow-water groups (reef fish, gastropods and seaweeds) from 11 Atlantic archipelagos. We here express our concerns regarding the data accuracy used to compute the different models that tested the null hypothesis of species richness being independent of the selected variables. In our commentary, we focus mainly on the use of out-of-date checklists of gastropod and seaweed species from different archipelagos, but we also point out inaccuracies in some island age estimates and explain our disagreement with the use of the 200 m depth limit for the shallow-water gastropods and seaweeds.

Keywords Atlantic Ocean, endemism, gastropod, island age, littoral area, marine island biogeography, seaweed, species richness

Compared with terrestrial island biogeography, marine island biogeography is still in its infancy and papers that respond to this quest should thus be most welcomed by the scientific community. We have read the paper by Hachich *et al.* (2015) with great expectation. This paper intended to test the large-scale biogeographical patterns of the species–area, species–island age and species–isolation relationships, using marine shallow-water groups (reef fish, gastropods and seaweeds) from 11 Atlantic archipelagos. Several models were used to test the null hypotheses of species richness being independent of the selected variables. The biogeographical patterns were found to be highly taxon-dependent, with area, island age and isolation showing the theoretically expected correlations for seaweeds; however, no correlation was found between reef fish/gastropods species richness and isolation.

Although we acknowledge the effort of the authors and highlight that this is one of the few papers we are aware of that study island biogeographical patterns focusing on marine organisms and habitats, in our opinion, this article has several problems:

1. The authors cite Briggs (1966) to support a supposed lack of endemic marine species on Bermuda, Azores and Canaries as a result of Pleistocene glaciations. This hypothesis was refuted in *Journal of Biogeography* (Ávila *et al.*, 2008a). Pleistocene glaciations did not affect the marine gastropod endemic stock (Ávila *et al.*, 2009, 2015). However, thermophilic species, which had reached higher latitude Atlantic islands as a result of range expansions during glacial terminations and/or during Pleistocene interglacials and related sea-level highstands, were indeed impacted by glacial episodes and locally disappeared, as well as most of the species associated with sandy environments, which were locally extirpated from all oceanic islands every time the sea level dropped below the shelf edge of the island (Ávila *et al.*, 2008b). A glacial termination is the short period between the end of glacial and the establishment of interglacial conditions.

2. Assembling reliable state-of-the art checklists is a laborious and time-consuming task. Moreover, this is a never-ending story, as new species keep being described every year. This is particularly the case in the archipelagos studied here because some of them are insufficiently explored. Nevertheless, a good job in the compilation of data allows biogeographical patterns to emerge. There are at least nine references not reported by Hachich *et al.* (2015) since Ávila's (2000) account on the shallow-water marine molluscs of the Azores, with 126 new records/confirmation of old/dubious records, of which 12 were new endemic species described for the archipelago; thus, Hachich *et al.* (2015) reported 216 shallow marine gastropods for the Azores, whereas the number is now 278. For Madeira, there is a recent book on marine molluscs that the authors failed to check (Segers *et al.*, 2009), increasing the numbers from 175 to 396. The same happened with recent checklists for the Canary Islands (Rolán, 2011); as a consequence, the number of gastropods for Canaries should not be 'NA' (not available), as quoted by Hachich *et al.* (2015), but instead 861 species.

3. In our opinion, the available gastropod checklists from Saint Helena and Ascension Island are old, outdated and less reliable than those from other Atlantic archipelagos. A large number of additional species has recently been detected at both islands (F. Swinnen, pers. comm. to PW) and these new data may improve the resolution of detected biogeographic trends.

4. Similar reasoning applies to the seaweed richness, although the differences detected are much smaller than those for gastropods. Again, important recent checklists of macroalgae from the Azores, Madeira, Canaries and Cape Verde have not been consulted/mentioned therefore it is not surprising that differences occur between the reported values of Hachich *et al.* (2015) and current values from checklists kept by algae experts. For example, according to a review paper of the Macaronesian seaweed by Neto *et al.* (2014), Madeira has at least 432 species instead of the reported 369 and Cape Verde has 345 instead of 317 species.

5. Hachich *et al.* (2015) could have also tested the endemic gastropod richness versus area, age and isolation, as there are good data available for six biogeographical units: the Azores, Bermuda, Madeira, Canaries, Cape Verde and Fernando de Noronha.

6. There are also problems with the oldest subaerial ages used by Hachich *et al.* (2015) for Madeira (14.3 Ma), the Azores (8.12 Ma) and Cape Verde (15 Ma) archipelagos. The oldest island of the Madeira biogeographical unit is Porto Santo, with a reported age of 18.8 Ma (Mata *et al.*, 2013); the oldest island of the Azores biogeographical unit is Santa Maria, with a reported age of 6.3 Ma (Ramalho *et al.*, 2014); finally, the oldest island of the Cape Verde biogeographical unit is Sal, with a reported age of 15.8 Ma (Ramalho, 2011).

7. A second and different motive of concern is related with the areas used for gastropods and seaweeds. Hachich *et al.* (2015) used the same area for the three groups analysed, defined as the 'shallow shelf surface of the islands, measured as the sea-bottom area down to 200 m depth'. We strongly disagree with the use of the 200 m depth limit for the shallow-water gastropods and for the algae. Algae are restricted to the euphotic zone. In isolated volcanic oceanic islands algae are common down to 40–50 m, and sometimes even at greater depths. As many gastropods live in close association with algae that provide them shelter and food, marine ecologists usually define as a shallow-water habitat the area between the intertidal and the depth of disappearance of most algae (*c.* 50 m depth). Therefore, in our opinion, all calculations used by Hachich *et al.* (2015) for gastropod and seaweed richness in relation to area are misleading and, as a consequence, their conclusions might be erroneous.

8. The use of a global bathymetric database (Shuttle Radar Topography Mission, SRTM30_PLUS) which has a small resolution (1 km^2), instead of much more reliable state-of-the-art bathymetric compilations which are currently available (e.g. the Azores and Canaries) certainly results in inaccurate areas for the studied archipelagos. Yet, as no detailed bathymetry exists for all archipelagos, we accept that, as a first approach and with some precautions, this methodology might be used for this kind of analysis.

The discussion above illustrates our concerns regarding the use of reliable and up-to-date checklists before use of these data to extend well-established terrestrial biogeographic theories (MacArthur & Wilson, 1967) to the marine realm. Not only are the species numbers given too low in many cases but additional species are being discovered every year on these islands and at different rates. Bermuda and the Canaries are comparatively well-studied and the rate of increase in species numbers is much less than in places like São Tomé and Príncipe or even Madeira.

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