A CHANGING CLIMATE: PROSPECTS FOR THE AZOREAN BRYOPHYTES

Débora Henriques[1], Rosalina Gabriel[1], Márcia Coelho[1], Paulo A.V. Borges[1]

[1] Azorean Biodiversity Group (ABG, CITA-A) and Portuguese Platform for Enhancing Ecological Research & Sustainability (PEERS), Dpt of Agrarian Sciences, University of the Azores;

Email: debhenriques@uac.pt

CLIMATE CHANGE AND BIODIVERSITY

As climate change is warming our planet, biodiversity is responding to that input through several different processes, such as range or phenology shifts (Bellard *et al.*, 2012). The main problem with species' responses is that many seem to be unable to keep up with the fast pace of climate change. Quintero & Wiens (2013) established that projected rates of climate change until 2099 are about 10.000 times superior to the historical climatic niche evolution rates of 540 species of terrestrial vertebrates. If species' fail to adapt, local extinctions can occur. This is especially true for islands, due to isolation and dispersal barriers. Plants, for example, can only migrate upwards until they reach the mountain summits. From there, they have no place to go, no area to colonize.

BRYOPHYTES IN THE AZORES

As a result of isolation and topographic diversity, the nine islands of the Azores host a rich bryoflora. Currently, 480 bryophyte species and subspecies are known, 7 of which are endemic of the Azores and 14 of which are endemic of Macaronesia. In 1946, Allorge & Allorge suggested the altitudinal distribution of the Azorean bryoflora in 5 regions: the littoral or *Riccia* region, the *Echinodium* and *Neckera intermedia* region, the *Sphagnum* region, the *Adelanthus decipiens* and *Daltonia* region and the subalpine or *Andreaea rupestris* region, as shown in Figure 1. It becomes clear that the two upper stages and their bryophyte communities are mainly represented in Pico, with the uppermost stage being restricted to this island.

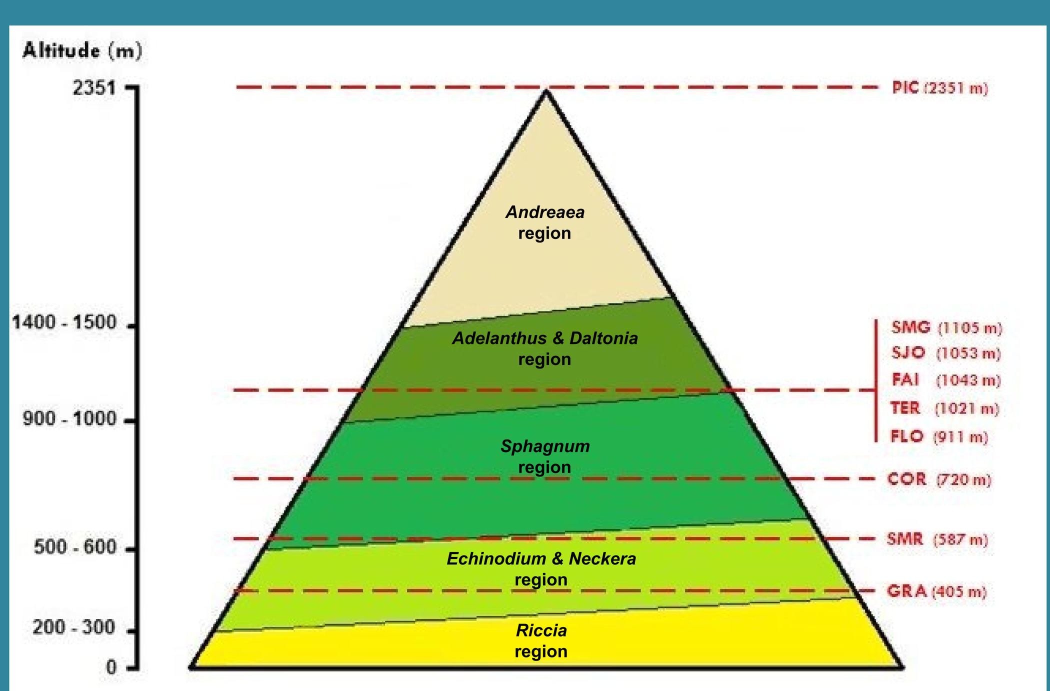

Figure 1

Schematic representation of the altitudinal distribution of Azorean bryophytes in 5 regions (based in Allorge & Allorge, 1946).

The red dashed lines represent the nine islands maximum altitudes: PIC – Pico, SMG – São Miguel, SJO – São Jorge, FAI – Faial, TER – Terceira, FLO – Flores, COR – Corvo, SMR – Santa Maria and GRA – Graciosa.

TACKLING THE PROBLEM

In order to determine possible future impacts of predicted climate changes (IPCC, 2007) on the Azorean bryoflora, an altitudinal gradient was sampled on Terceira island in September 2012 at 200 m intervals, following the BRYOLAT/MOVECLIM methodology. The resulting distribution and abundance data for epiphytic bryophytes, along with several climatic variables, will be used to model future bryophyte distribution on the island as a response to projected climate changes.

What are we expecting to find?

1) A peak in species richness at medium altitudes, according to the mid-domain effect hypothesis (Colwell & Lees, 2000);

2) Distribution limited by abiotic and geographic factors, resulting in the contraction of species ranges, range shifts to higher altitudes, species disappearance or extension due to habitat change and some variation on ecosystem service levels.

PRELIMINARY RESULTS

The preliminary results for Terceira island, after identification of the samples to the genus level, are represented in Figures 2 and 3.

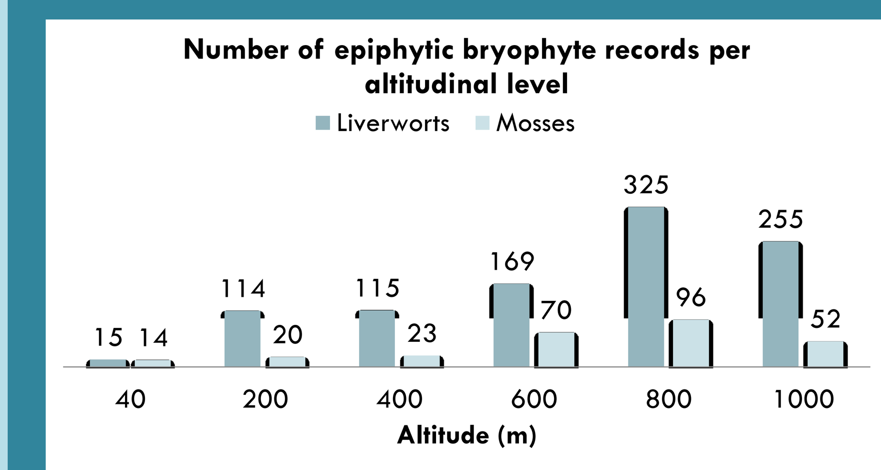

Figure 2

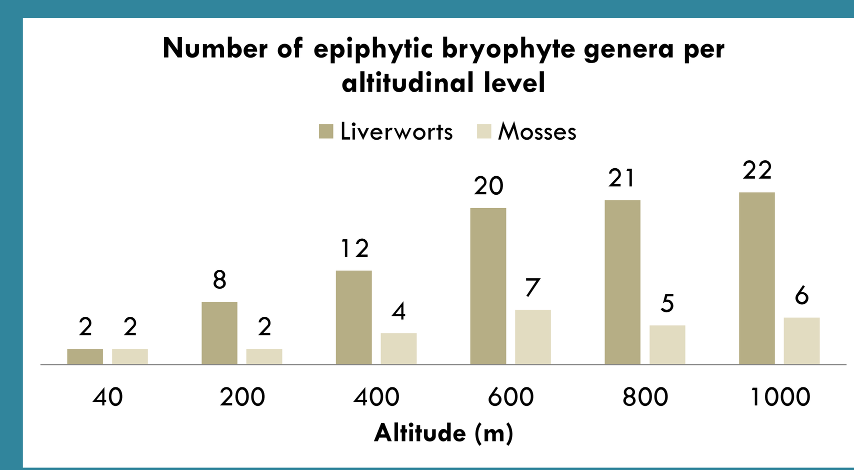

Figure 3

For Terceira's epiphytic bryophytes, the richest altitudinal levels appear to be the 800 m (421 records) and the 1000 m (307 records) corresponding to 26 and 28 different genera, respectively. This, it seems that the mid-domain effect hypothesis won't be able to explain this diversity gradient, but further modeling is required in this matter. Note that there is some anthropogenic disturbance at medium altitudes (200-400 m).

BACK TO THE FUTURE

Applying the schematic illustration depicted in Figure 1 and representing the altitudinal levels of the gradient, we can easily detect that the *Adelanthus* and *Daltonia* region occupies a narrow portion of the territory, being restricted to the interval between 900 m and the island summit, at 1021 m (Figure 4).

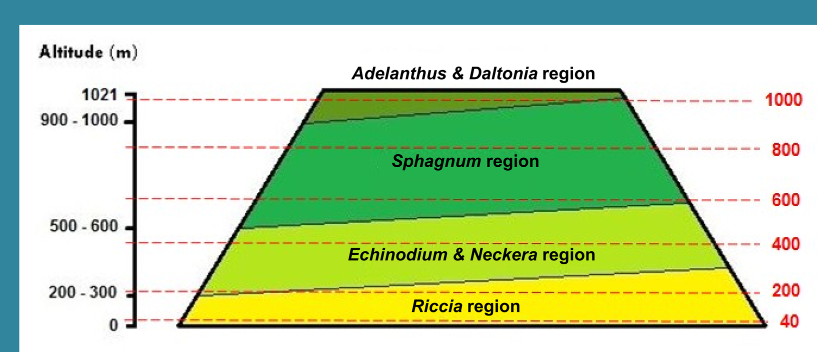

Figure 4
Schematic representation of the proposal for the altitudinal distribution of Azorean bryophytes in 5 stages applied to Terceira island.

Applying directly the temperature variation projections of two IPCC (2007) scenarios (B1 and A1F1) to the gradient climatic data (Table 1), we can roughly visualize what the possible changes in temperature may imply for Terceira's bryoflora until the end of the century (Figure 5).

Altitude (m)	Actual mean T (°C)	Projected mean T 2099 (°C)	
		B1	A1F1
1000	11.6	13.4	15.6
800	12.8	14.6	16.8
600	13.6	15.4	17.6
400	15.3	17.1	19.3
200	16.5	18.3	20.5
40	18.3	20.1	22.3

Table 1
Gradient climatic data combined with IPCC (2007) projections

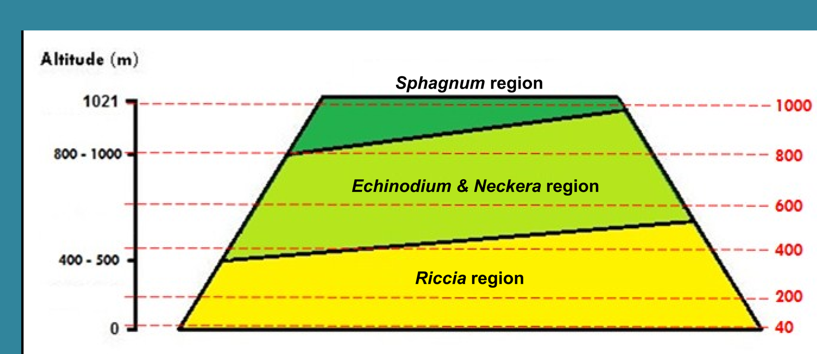

Figure 5
Representation of the possible future reality of Terceira's altitudinal regions in response to climate change

A 200 m climb of the altitudinal stages would cause the disappearance of the uppermost region, where we found the highest number of liverwort genera (22), and a drastic decline of the *Sphagnum* region, where we found most records for epiphytic bryophytes (421). Also, five bryophyte genera found only between the 800 m and 1000 m would be in danger.

Rigorous modeling techniques will be applied to the existing data in order to improve our predictions, but despite the ocean's probable moderating effect, there are strong signs that the Azorean bryoflora distribution and composition will suffer some changes until the end of the century.

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