Niche overlapping points to the ecological divergence between populations of *Abies pinsapo* at both sides of the Mediterranean Sea

Antonio González Hernández[1], Diego Nieto Lugilde[2], Julio Peñas[1], Matthew Fitzpatrick[3], Francisca Alba Sánchez[1]

1 Dpto. de Botánica, Universidad de Granada
2 Dpto. de Botánica, Ecología y Fisiología Vegetal, Universidad de Córdoba
3 Appalachian Laboratory, University of Maryland Center for Environmental Science

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Introduction

In a complex group of organisms, outlining the niche characteristics can contribute to resolve taxonomic differences, that is crucial to the conservation of biodiversity.

Abies pinsapo is a tree complex species distributed in the Gibraltar Arc, included in the IUCN Red List as Endangered (Arista *et al.*, 2011), which internal taxonomy has been discussed (Sękiewicz *et al.*, 2013). Differences found in morphometrical traits (Sękiewicz *et al.*, 2013) and genetic divergence (Sánchez-Robles *et al.*, 2014) give some authors arguments to consider two different species: *A. pinsapo* Boiss. for Iberian populations, and *A. marocana* Trabut. for the African ones.

We aim to elucidate ecological differences between populations of *Abies pinsapo* complex at both sides of the Mediterranean Sea (Betics in the Iberian Peninsula, and Rif in North Africa) by testing the overlap between their niches in environmental and geographical spaces.

Methods

We analysed intercontinental differences between the niches of Betics and Rif of *Abies pinsapo* complex populations. We contrasted these results with the intracontinental analyses in which two Betic subpopulations (Grazalema and Sierra de las Nieves) were compared.

Niches were defined by five environmental variables derived from Worldclim-Global Climate Data (http://www.worldclim.org) and FAO Soil Portal (http://www.fao.org/soil-portal) (Fig. 2).

Niches of different populations were projected as bidimensional density grids onto the environmental space, resolved by the two main axes of a PCA on five variables (Broennimann *et al.*, 2012).

Niche overlap between population pairs was calculated using the Schoener´s *D* index, which was contrasted in equivalency and similarity tests (Warren *et al.*, 2008).

Additionally, niches were projected onto the geographical space by Species Distribution Modelling –`MaxEnt`, included in `dismo` package of `R` (Hijmans *et al.*, 2014).

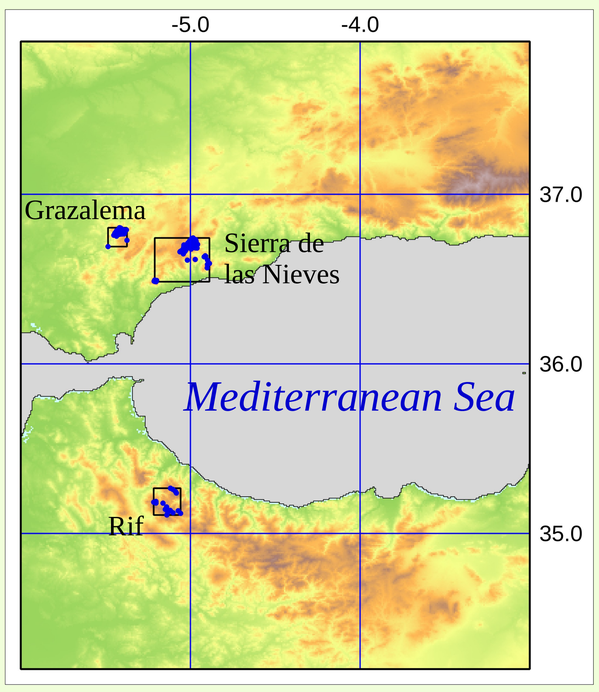
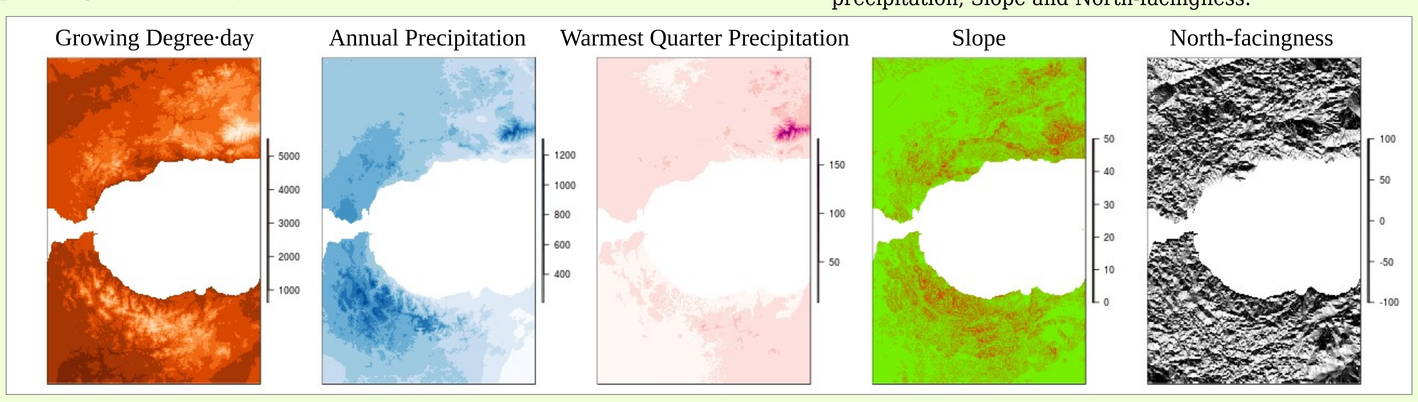


Figure 1. Study area: *Abies pinsapo* complex is distributed in the Gibraltar Arc. Two main populations (Grazalema and Sierra de las Nieves) in the Betic mountains, Iberian Peninsula), and one in the Rif (Morocco). Boxes bounding the three populations indicate the surrounding context used to define the environmental space in overlap analyses.

Figure 2. Predictors used in niche analyses: Growing degree·day, Annual precipitation, Warmest quarter precipitation, Slope and North-facingness.



Results

In the intercontinental analysis, projections of Betic and Riffian niches on the environmental space showed their ranges relatively shifted along a gradient; on the contrary, both Betic populations share the same environmental space in the intracontinental analysis.

Equivalency and similarity tests showed significant niche divergences between populations at each side of the Mediterranean, whereas divergences between the two Iberian populations were non-significant.

Consistently, geographical projections show a weak overlap between niches in the intercontinental analysis, whereas niches of the two Betic populations were almost coincident.

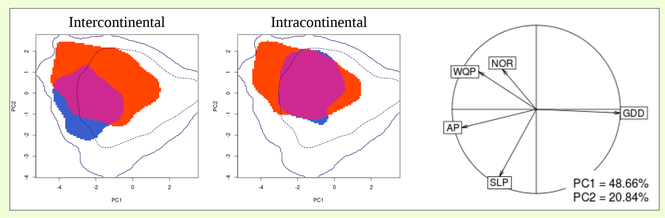
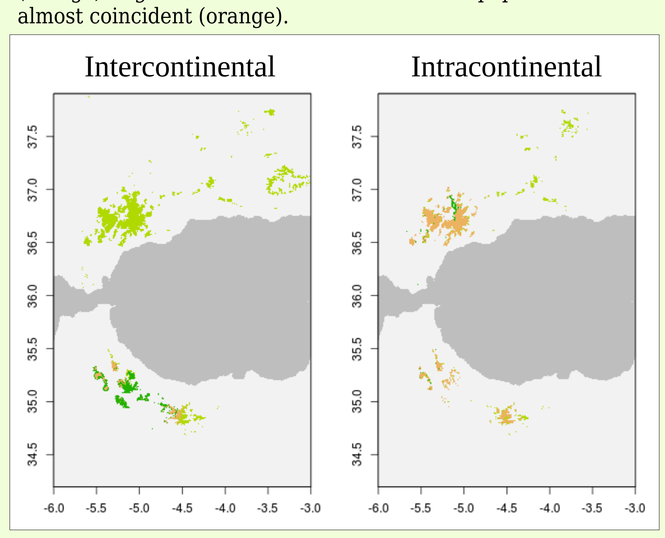


Figure 3. Niche overlap in the two dimension environmental space. Niches are depicted over a 100 × 100 cell grid determined by the two main axes of a PCA on five descriptors. Red and blue polygons represent different population niches; purple polygon shows the common niche (overlap).

Table 1. Niche overlap, and equivalency and similarity tests in the intercontinental and intracontinental population pairs analysed. *D:* Schoener's index. Similarity test implies two asymmetrical analyses by population pair (niche → surrounding context; 1 and 2 represent first and second population in each pair). * Significant at $P < 0.05$; ** Significant at $P < 0.01$; *ns*: populations are not significantly similar each other.

Population pairs	Overlap (*D*)	Equivalency	Similarity 1→2	Similarity 2→1
Betics-Rif	0.37	Non-equivalent**	*ns*	*ns*
S Nieves-Grazalema	0.68	Non-equivalent*	Similar**	Similar*

Figure 4. Niche overlap in the geographical space modeled by `MaxEnt`. *Left*: Suitable habitat of populations at both sides of the Mediterranean Sea (in light and deep green) barely overlap (orange). *Right*: Suitable habitat of both Betic populations are almost coincident (orange).



Conclusions

In line with previous studies on morphological traits and genetics, niche analyses show climatic niche differences between African and Iberian populations. These results, reinforce the idea of segregation of *Abies* populations into two different taxa: *Abies pinsapo* Boiss. and *Abies marocana* Trab.

Acknowledgements

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