

Phyloclimatic Modelling: Phylogenies, Palaeo-climate and Environmental Preferences

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What is phyloclimatic modelling? Techniques for optimising environmental characteristics across phylogenetic trees are widely used, as are techniques to build bioclimatic models from data such as annual means of temperature and precipitation. Phyloclimatic modelling combines these two techniques to produce bioclimatic models for ancestral lineages and projects these models into relevant palaeo-climate scenarios. This is done by using a temporally calibrated phylogeny.

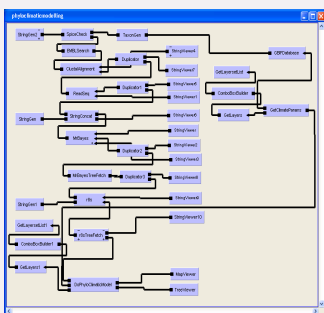


Figure 1: A BiodiversityWorld workflow to do phyloclimatic modelling



Cyclamen coum
Photo, S.L. Jury



Neotype of
Cyclamen creticum

BiodiversityWorld is a pioneering problem solving environment (PSE) using the workflow manager Triana (<http://www.trianacode.org>) built on GRID technology. This PSE contains tools for data collection, phylogenetic analysis, and bioclimatic modelling. Having these tools together in an integrated system allows us to reconstruct bioclimatic models on phylogenies. This analysis requires gathering DNA sequence data, locality and climate data, followed by its combined analysis. Figure 1 shows a BiodiversityWorld workflow that will perform this analysis.

Cyclamen is a small genus (c.20 species) within the family *Myrsinaceae* growing around the Mediterranean basin (Map 1). They occur in the Mediterranean-type climate zone, characterised by hot-dry summers and cooler-wet winters which arose around 15-10mya. What role has the surrounding climate played in the evolutionary development of *Cyclamen*?

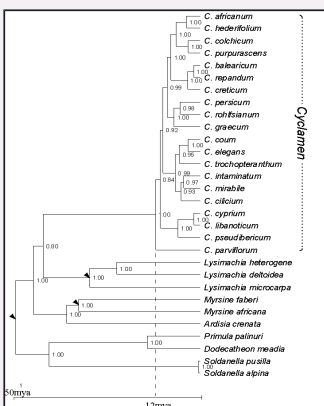
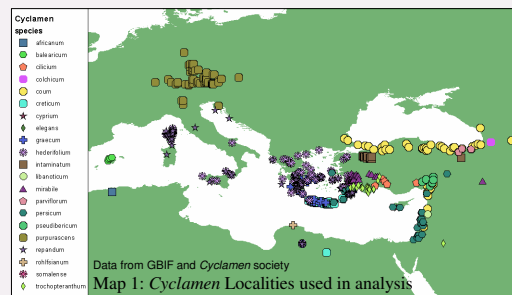
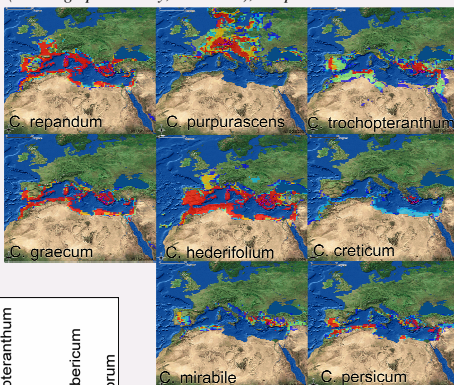


Figure 2: Optimal Bayesian topology from combined analysis of ITS and trnL-F. Branch probabilities are marked at internal nodes. Time calibration using penalised likelihood in r8s. Calibration points marked with triangles.

Map 2: Bioclimatic models (GARP) for selected *Cyclamen* species.

(red=high probability, blue=low), Purple dots=Localities



Results: *Cyclamen* diversification is shown to have begun approx 12mya (Fig. 2). This diversification is synchronous to the formation of the Mediterranean-type climate zone (15-10mya). Although the genus occupies the whole of the Mediterranean, individual species have their own climatic niches (Map 2).

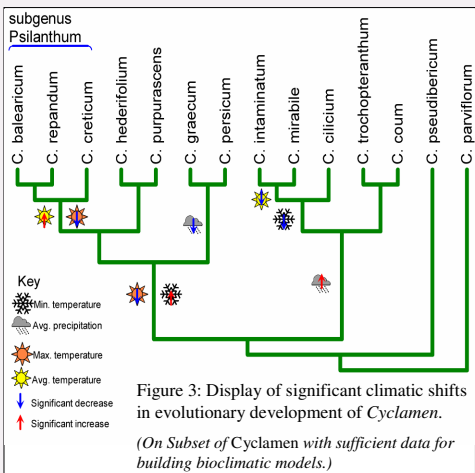
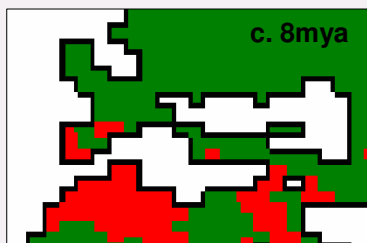


Figure 3: Display of significant climatic shifts in evolutionary development of *Cyclamen*. (On Subset of *Cyclamen* with sufficient data for building bioclimatic models.)



Map 3: Bioclim model for ancestral lineage of *Cyclamen* subgenus *Psilanthum* based on variants of Temperature and Precipitation. (red=suitable climate) Resolution=1 degree squared

The evolutionary development of *Cyclamen* has seen several major climatic shifts amongst the ancestral lineages (Fig. 3). The ancestral lineage to subgenus *Psilanthum* saw a significant shift in average and maximum temperature ranges. The bioclimatic model for *Psilanthum* demonstrates the suitable climate at the birth of this lineage (Map 3). This demonstrates that phyloclimatic modelling produces reasonable climatic predictions which could be used to estimate ancestral distributions. It will also help us to understand the impact of climate change on evolution.