Incorporating phylogeography for modelling the distribution of the carob tree (Ceratonia siliqua, Leguminosae) in future climate change
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A range contraction in the Mediterranean is predicted for carob tree due to climate change. Overlap analysis of climatic niches as well as Maxent modelling indicate that incorporating phylogeography may improve carob distribution modelling and forecasting. In contrast with forecast done at the species level, the analyses done at the genetic groups level support SM, and EM as the most likely persistent areas whereas the most affected would be SS.


The carob is an evergreen termophilous fruit tree widely harvested throughout the Mediterranean for food and forage since antiquity. Currently, the carob is found in cultivation in orchards or in association with other crops, and it has expanded towards industrial, agricultural and soil restoration purposes. Wild populations are found in shrublands, forests as well as rocky outcrops and temporary river banks.

Two distinctive lineages diverged after a strong historical bottleneck, which subsequently split in four genetic clusters across the Mediterranean (SM, South Morocco; SS, South Spain; CM, Central Mediterranean; EM, East Mediterranean). Admixture is frequent due to human dissemination, such as in the North Moroccan populations (NM) which show assymetric introgression between Eastern and Western genetic clusters.

795 points, 6 climatic variables, linear, quadratic and interaction features

Selected climatic variables (Worldclim DB):
Anmp: Mean annual temperature
Maxtwm: Maximum temperature warmest month
Mintcm: Minimum temperature coldest month
Prec: Precipitation seasonality
Twetq: Mean temperature of wettest quarter
Tsea: Temperature seasonality

Red : probability of presence 0.8-1
Grey: probability of presence 0.25-1
Green points: carob occurrences

Carob phylogeography from Viruel et al. in press *

Current
2070 RCP 4.5

Analysis of the overlap between current and future (2070) climatic envelops

Data for the future were obtained by averaging the result of 3 GCM models (CNRM-CM5, HadGEM2-ES, CCSM4). Green, orange and red points correspond to the current period and to the RCP scenarios 4.5 and 8.5 respectively.

A principal component analysis was done and used for a between class analysis (BCA) with the climatic change scenarios as factor. The first axis (BCA_1) corresponding to temperature is the most correlated to climate change forecasting.

Box plots of the distribution on BCA_1 axis of the five genetic clusters

Between class analysis with climatic scenarios as factor

New forecasting done with Maxent in respect to phylogeography and averaging results of 3 GCMs for RCP 4.5

SM
NM
SS
CM
EM

Current
2070 RCP 4.5
2070 RCP 4.5
2070 RCP 4.5
2070 RCP 4.5
2070 RCP 4.5

How much change ?

Pessimistic forecasts?
What happens if the climate niche is divided according to phylogeographic structure?

Warmer
Cooler

https://dynamic.cirad.fr