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Mediterranean carob populations, native or naturalized?

A continuing riddle.

Juan Viruel¹, Fr d ric M dail¹, Marianick Juin¹, Anne Haguenaer¹, Gonzalo Nieto Feliner², Magda Bou Dagher Kharrat³, Stefano La Malfa⁴, Lahcen Ouahmane⁵, Herv  Sanguin⁶, Alex Baumel¹

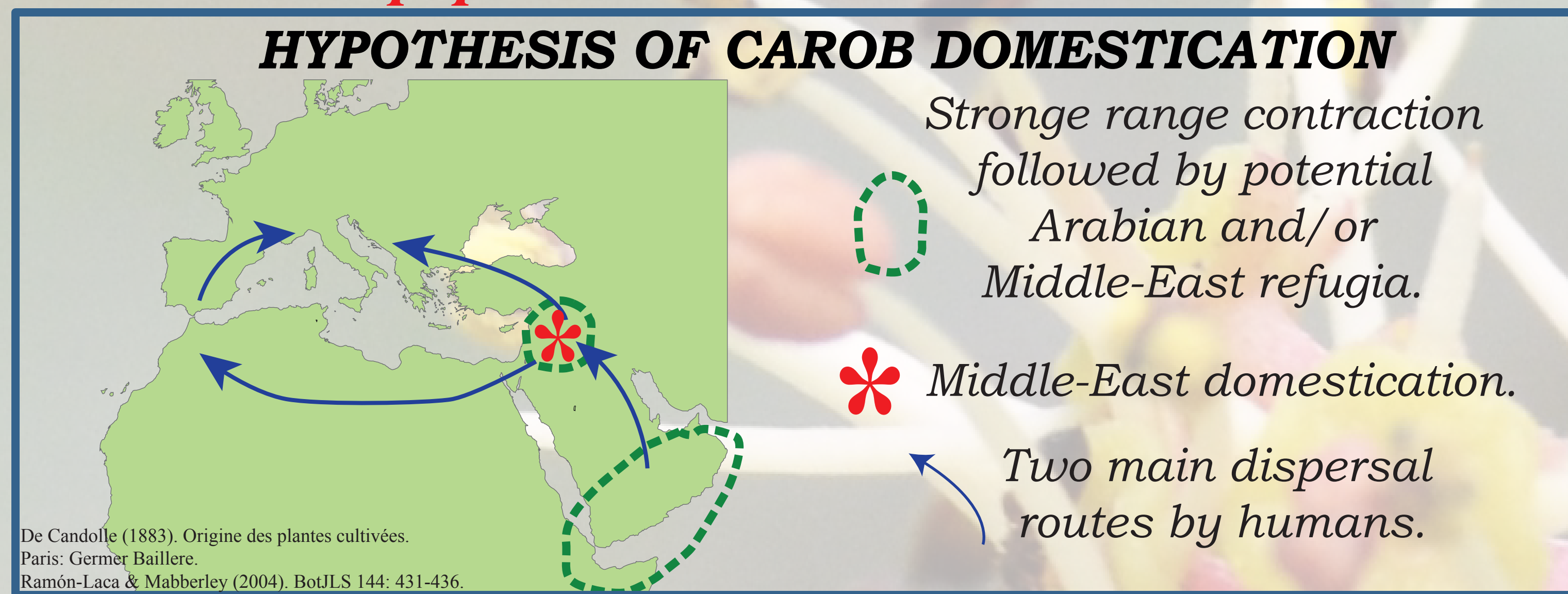
INTRODUCTION

Carob (*Ceratonia siliqua* L.) is a well-known Mediterranean tree which was probably domesticated contemporaneously to the first trees (eg. olive, fig) in the Middle-East. Since then, carob has played a crucial role due to its edible fruits used for cattle forage and subsistence agriculture. Carob plants are able to grow on stressful rocky soils, increasing the socio-economic value of many dry lands.



Carob with oaks and olive trees in Anti Atlas Mountains, Assif Oumarhouz, Morocco.

Despite its economic importance, the origins and history of carob populations are still under debate.



OBJECTIVE

Reconstructing the most probable origin of the Mediterranean distribution of carob by contrasting natural *versus* human-mediated expansion.

MATERIALS AND METHODS

- Three cpDNA regions sequenced for 49 populations of *C. siliqua* and two of *C. oreoethauma*. Haplotype network was based on coalescence model.
- Environment Niche Modeling (ENM) reconstruction using 1,000 presence points for present, Mid-Holocene, Last Inter-Glacial (LIG) and Last Glacial Maximum (LGM).
- Divergence time estimations using a relaxed-clock model.

RESULTS

Three haplotypes were found within *C. siliqua* with a strong geographic structure. The western haplotype of *C. siliqua* showed the higher probability of ancestry. *C. oreoethauma* haplotype is significantly different to those in its congener (Fig. 1).

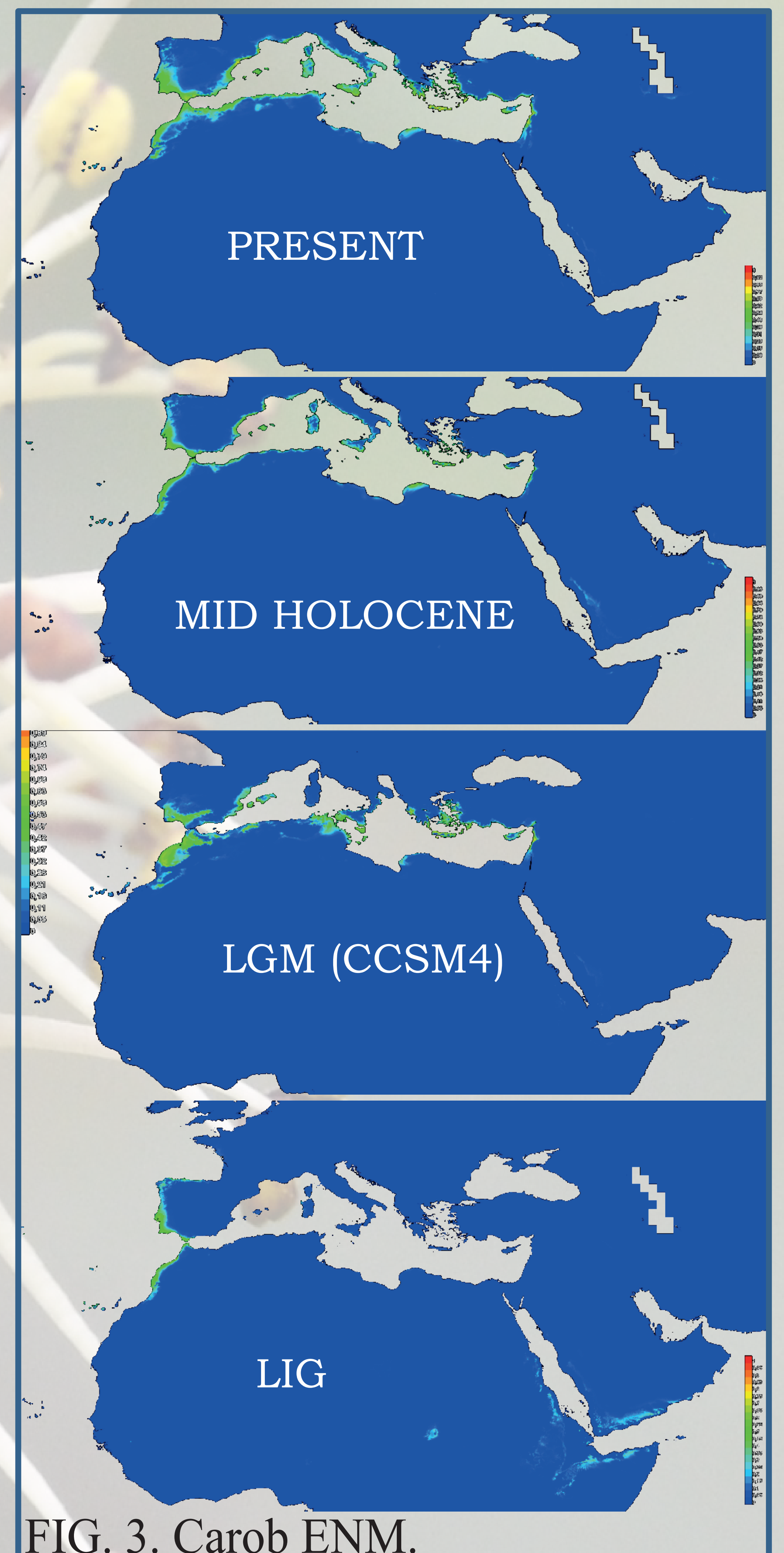


FIG. 3. Carob ENM.

Divergence time estimations determined that the split between *C. oreoethauma* and *C. siliqua* was 9.0 (17.6-2.6) mya, and that among the two main phylogroups found within *C. siliqua* at 1.6 (5.0-0.01) mya. These results also support a natural distribution of carobs in the Mediterranean.

CONCLUSIONS

Our results supports a natural Mediterranean distribution of carob before the emergence of agriculture. Multiple origins of domestication from native populations would explain the genetic structure.

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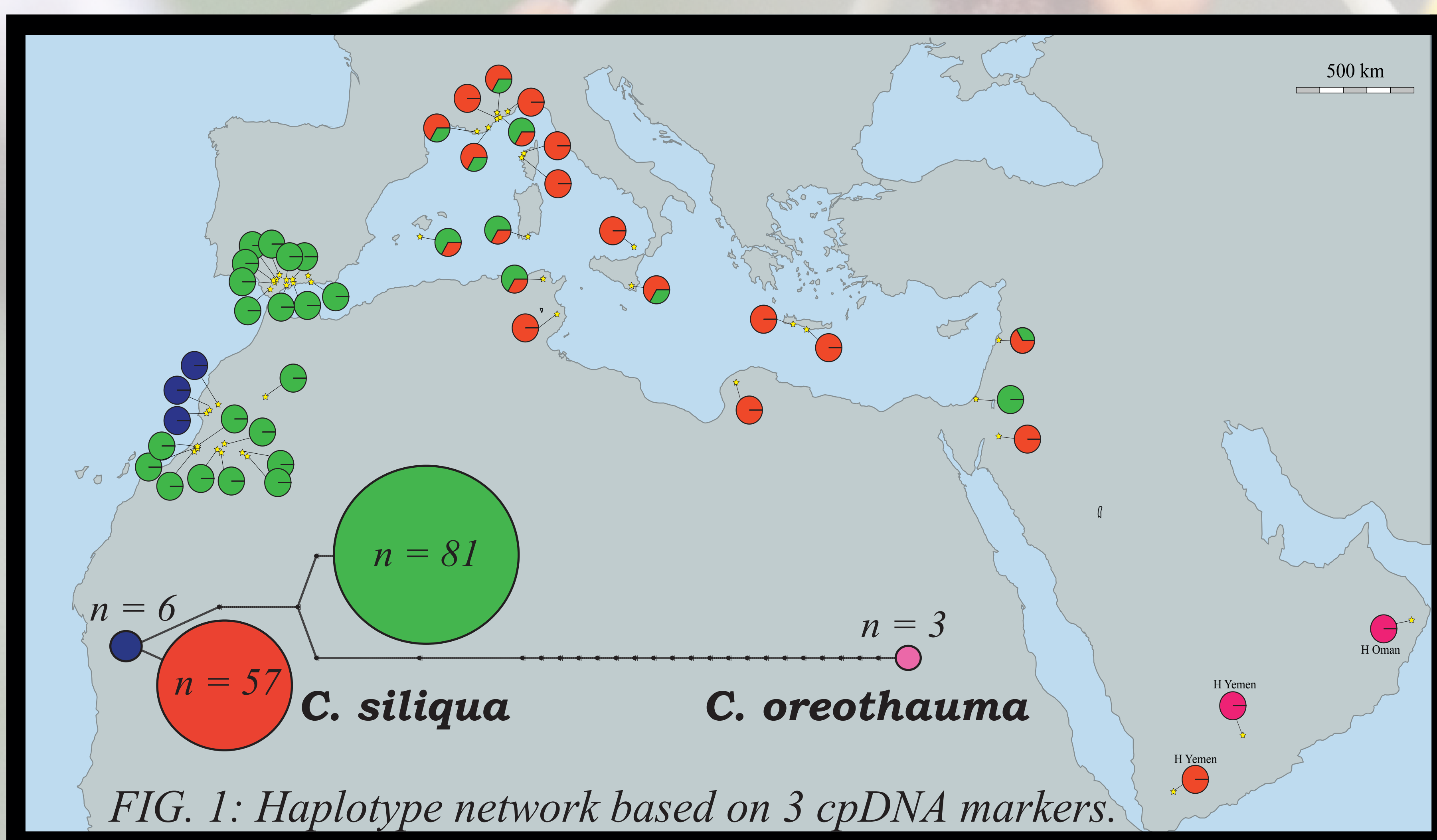


FIG. 1: Haplotype network based on 3 cpDNA markers.

Current climatic niche conditions have determined the distribution of carob at present (Figs. 2, 3) and its history throughout climatic oscillations (Fig. 3). Carob shows a high sensitivity to frost, with a cold limit in winter at 4.6  C and an optimal at 10  C (Fig. 2).

ENM-based potential distributions (Fig. 3) showed that climatic conditions would have allowed the expansion of carob throughout the Mediterranean since LGM to Mid-Holocene times, preceding the putative dispersal hypothesis by humans.

