

Past climate change explain the phylogeography of *Vitellaria paradoxa* over Africa

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INTRODUCTION

Given forecasts on anthropogenic climate change, the becoming of African Savannah biome is hazardous. We address in this study the range-wide phylogeography of *Vitellaria paradoxa*, an IUCN's red list vulnerable but economically major sub-Saharan savannah tree, in connection with Quaternary climate oscillations to identify specific conservation strategies.

In this purpose, we examined genetic structure of 71 populations within species natural range using chloroplast and nuclear SSRs and predicted ancient distribution of the species.

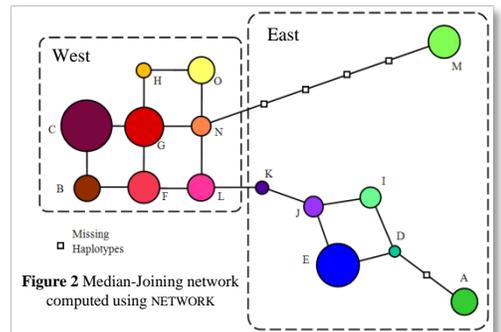


Figure 2 Median-Joining network computed using NETWORK

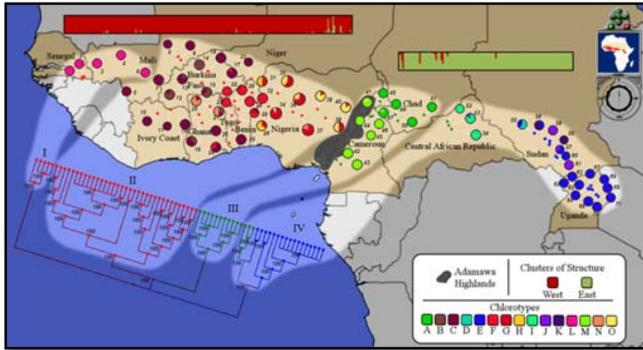


Figure 1 Distribution of the populations of *V. paradoxa* with: (A) Bar plot of clustering of individuals made by STRUCTURE (7); (B) geographic distribution of the fifteen chlorotypes of *V. paradoxa*; and (C) Unrooted neighbor-joining tree drawn with GENGIS (14).

MATERIAL & METHODS

Material

374 trees belonging to 71 populations distributed over 14 sub-Saharan countries, including the two non-overlapping subspecies (*paradoxa* and *nilotica*) were genotyped using 12 nuclear SSRs markers (7) and 3 chloroplast SSRs: Ccmp3, Ccmp5 (2) and Ntcp9 (3).

Statistical analyses

Classical diversity indices were computed for each populations and their variation explored using Neighbor Association Procedure (NAP) (4). Levels of differentiation were assessed by Analysis of MOlecular VAriance (AMOVA) (6). Differentiation indices based on unordered (F_{ST} ; C_{ST}) and ordered alleles (R_{ST} ; N_{ST}) were computed and compared to test phylogeographic signal using SPAGEDI (6). Bayesian inference of clusters was performed using STRUCTURE (7). A haplotype frequency-based Neighbour-joining tree was built using PHYLIP (8) and a median-joining network (9) by NETWORK program.

Ecological Niche Modeling

Climate preferences of *V. paradoxa* over 126 populations were used to address Actual (10), Last-Glacial Maximum (LGM, 11) and Last Inter-Glacial (LIG, 12) distributions of the species using BIOCLIM algorithm based on homocline matching using DIVA-GIS (13).

RESULTS

Genetic structure and differentiation

We identified 15 chlorotypes: 8 closely related chlorotypes in West Africa; 7 in eastern zone with stepwise mutations (Figs 1 & 2). NAP revealed higher diversity in West Africa. We detected a strong differentiation in 3 groups (West/Central/East) with a strong phylogeographic signal for nuclear ($F_{ST} = 0.21$, $R_{ST} = 0.28$ and $R_{ST} > pR_{ST}$) and chloroplast SSRs ($C_{ST} = 0.81$, $N_{ST} = 0.90$ and $N_{ST} > pN_{ST}$). Bayesian analysis of STRUCTURE reveals strong differentiation ($K = 2$) between East and West with a possible substructure detected at $K = 4$ distinguishing Central and East African populations. The unrooted NJ tree confirmed the strong differentiation, distinguishing extreme western populations in a single clade I but clustering almost West African populations in a monophyletic group (Clades II), and splitting East group in two clusters (Clades III and IV) (Fig. 1C).

Actual & Ancient Theoretical Distribution

Ecological niche modeling was predicted in three epochs (Fig. 3):

Actual suitable area of *V. paradoxa* is fully consistent with real distribution.

LGM (~20,000 YBP) suitable area of the species is good in West Africa but very fragmented at the East of Adamawa Highlands, with reduced area around Chad Lake, in northern Congo and Uganda.

LIG (~130,000 YBP) suitable area reveal that potential distribution of the species was large but already structured in 3 groups before LGM perturbation.

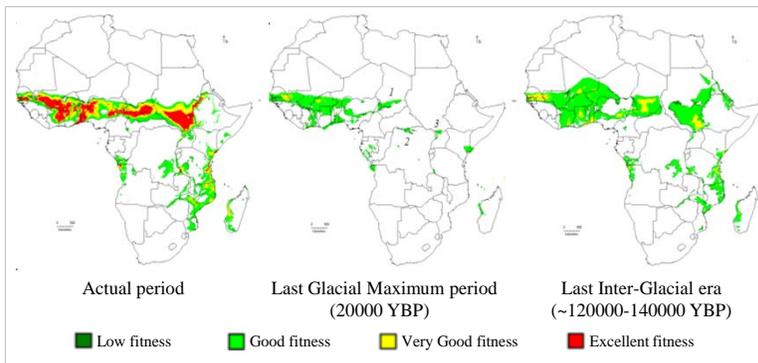


Figure 3 Fitness of *V. paradoxa* predicted by Ecological Niche Modeling (13)

"...Savannahs are anticipated to be among the most sensitive ecosystems to future changes ... understanding of factors that structure savannah communities is urgently required to guide management efforts"

Sankaran et al.
 Nature 438, 846 (2005)

DISCUSSION

A phylogeographic pattern driven by climate changes

We suggest that the East-West phylogeographic structure of *V. paradoxa* is due to past climate shifts and particularly to Last Glacial Maximum. We propose that *V. paradoxa* was maintained in West Africa due to positive effect of monsoons from Gulf of Guinea (16), explaining the weak structure within this 3,000 km wide area, resulting in higher diversity level. Conversely, we suggest that a possible deeper impact of LGM perturbation induced the constriction of the species in putative glacial refugia in East Africa, resulting in the strong differentiation and the weak level of diversity in this zone. Finally, we proposed that the differentiation between East and West has been maintained across ages by Adamawa Highlands peaking at 1,300 between Nigeria and Cameroun.

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Prospects for conservation of *V. paradoxa* in African Savannah biome

Realistic prospects on global warming predict an increase of 2-3 °C within next 100 years in sub-Saharan Africa (16). Given this actual anthropogenic climate change, can we project conservation priorities for *V. paradoxa*? In light of deep past perturbations detected in the eastern zone, we suggest that actual global warming will probably threat this area and large effort should be given to protect *V. paradoxa* in this zone. Due to buffering effect of monsoon in Guinean lands functions, West African populations should be less affected, by we propose increasing efforts to keep this zone as a "diversity hotspot", identifying and protecting the numerous *V. paradoxa* landraces in West Africa.

