Genetic diversity analysis of a large cocoa trees collection from the Ecuadorian Amazon safeguarded for local and sustainable cocoa production

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The production of aromatic cocoa has a direct positive impact on the sustainability of the agricultural sector thanks to a significantly higher producer price paid to the farmer. Ecuador is the top cocoa-producing country in South America and the leading exporter of fine and flavor cocoa worldwide. The aromatic Nacional variety, emblematic of Ecuador, is highly sought after by the chocolate industry. Today, the cultivated "modern Nacional" is an hybrid population resulting from genetic mixing of 3 ancestors: Amelonado, Criollo and ancestral Nacional. A long collaboration has been established between INIAP (Instituto Nacional de Investigaciones Agropecuarias) and CIRAD (centre de Coopération Internationale en Recherche Agronomique pour le Développement) to discover the origin of the ancestral Nacional cocoa trees, to collect native cocoa trees in its area of origin (Ecuadorian Amazon), to safeguard and to use them for breeding of new aromatic varieties.

Context
Deforestation of parts of the Ecuadorian Amazon for crops cultivation and cow pastures

Diversity of habitats: altitudes (250 to 1200 m), temperature, cloud cover, rainfall

Genetic diversity due to the adaptation of cocoa trees to these environmental variations?

Our ambition
• Collect genetic resources related to the ancestral aromatic National variety poorly represented in germplasm collections.
• Safeguard collected trees at experimental stations and schools near the collection sites to evaluate agronomic traits.
• Evaluate the overall genetic diversity of cocoa trees in the Ecuadorian Amazon.

Collections
Four expeditions (2010, 2013, 2017 and 2019) have been organized in the Ecuadorian Amazonian provinces of Zamora-Chinchipe, Morona-Santiago and Pastaza with participation of farmers and Shuar, Achuar and Amazonian Kichwa Amerindian communities, to collect native cocoa trees.

Diversity of native cocoa trees in Ecuador
Phylogenetic tree inferred from 48 Simple Sequence Repeats (SSR) markers, 283 cocoa trees from 2010 to 2019 collections and accessions from Allen’s collections (1988). The new resources have greatly enriched the overall diversity of the cocoa tree, particularly around the Nacional and Curaray groups and an intermediate group near the village of El Panguí.

Genetic distribution and origin of Nacional
The Nacional genetic group is predominant in the south and Curaray in the north. An archaeological site has been discovered and analyses (including ancient DNA) have shown that the Maya Chichipe population was consuming cacao 5,000 years ago (Zarrillo et al., 2018).

The Mayo Chichipe population could have been involved in the domestication steps of the Nacional.

Conclusion / recommendation
This new collection shows that this region is a hotspot of cocoa diversity that enriches the currently known diversity and improves the knowledge of the genetic structure of T. cacao. Our results also clarify the geographical origin of the Nacional variety. These new resources will be used in breeding programs for the improvement of locally adapted aromatic varieties, and more globally for the selection of new varieties adapted to environmental changes. The collections were replanted near the collection sites so that local communities can easily access them and replant adapted cocoa trees to improve their income.

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