A genetic origin of fine or flavour cacao in southern Peru?

Evert Thomas, Thibault Chaillon, Bertus Eskes, Wilbert Cruz, Carlos Rodriguez, Odicio Campana, Wilton Cespedes
Allelic Richness

high

low

Genetic diversity and spatial structure in a new distinct *Theobroma cacao* L. population in Bolivia

Dupeng Zhang · Windsor July Martínez · Elizabeth S. Johnson · Eduardo Sornariba · Wilberth Phillips-Mora · Carlos Astorga · Sue Mischke · Lyndel W. Meinhardt

Geographic and Genetic Population Differentiation of the Amazonian Chocolate Tree (*Theobroma cacao* L)

Juan C. Motamayor1,2, Philippe Lachenaud3, Jay Wallace da Silva e Mota4, Rey Loor5, David N. Kuhn1, J. Steven Brown6, Raymond J. Schnell1
Allelic Richness (interpolation)

- high
- low
Geographic and Genetic Population Differentiation of the Amazonian Chocolate Tree (*Theobroma cacao* L)

Juan C. Motamayor, Philippe Lachaud, Jay Wallace da Silva e Mota, Rey Loor, David N. Kuhn, J. Steven Brown, Raymond J. Schnell
Locally Common Alleles (interpolation)

- high
- low
Geographic and Genetic Population Differentiation of the Amazonian Chocolate Tree (*Theobroma cacao* L)

Juan C. Motamayor1,2, Philippe Lachenaud3, Jay Wallace da Silva e Mota4, Rey Loor5, David N. Kuhn5, J. Steven Brown6, Raymond J. Schnell1
Subcluster 1

12k BP

Locally Common Alleles

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Allelic Richness (Na)</th>
<th>Shannon Information Index (I)</th>
<th>Locally Common Alleles (LCA)</th>
<th>Private alleles</th>
<th>Ho</th>
<th>He</th>
<th>Fixation index (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 8</td>
<td>7.12</td>
<td>1.33</td>
<td>0.28</td>
<td>0.70</td>
<td>0.40</td>
<td>0.68</td>
<td>0.41</td>
</tr>
<tr>
<td>Cluster 1</td>
<td>5.75</td>
<td>1.04</td>
<td>0.17</td>
<td>0.26</td>
<td>0.40</td>
<td>0.51</td>
<td>0.21</td>
</tr>
<tr>
<td>Cluster 10</td>
<td>5.23</td>
<td>1.00</td>
<td>0.18</td>
<td>0.16</td>
<td>0.36</td>
<td>0.50</td>
<td>0.28</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>4.23</td>
<td>0.88</td>
<td>0.04</td>
<td>0.07</td>
<td>0.45</td>
<td>0.47</td>
<td>0.04</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>3.67</td>
<td>0.63</td>
<td>0.04</td>
<td>0.02</td>
<td>0.15</td>
<td>0.33</td>
<td>0.54</td>
</tr>
<tr>
<td>Cluster 9</td>
<td>3.66</td>
<td>0.56</td>
<td>0.03</td>
<td>0.04</td>
<td>0.25</td>
<td>0.29</td>
<td>0.13</td>
</tr>
<tr>
<td>Cluster 7</td>
<td>3.33</td>
<td>0.66</td>
<td>0.12</td>
<td>0.07</td>
<td>0.30</td>
<td>0.36</td>
<td>0.18</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>2.41</td>
<td>0.40</td>
<td>0.03</td>
<td>0.01</td>
<td>0.11</td>
<td>0.29</td>
<td>0.49</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>1.77</td>
<td>0.19</td>
<td>0.17</td>
<td>0.10</td>
<td>0.02</td>
<td>0.10</td>
<td>0.77</td>
</tr>
</tbody>
</table>
Subclusters 1+2

Locally Common Alleles

12k BP
Subclusters 1+2+3

Locally Common Alleles

12k BP

<table>
<thead>
<tr>
<th></th>
<th>Allelic Richness (Na)</th>
<th>Shannon Information Index (I)</th>
<th>Private alleles</th>
<th>Ho</th>
<th>He</th>
<th>Fixation index (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nacional cultivar</td>
<td>1.53</td>
<td>0.21</td>
<td>0.05</td>
<td>0.12</td>
<td>0.13</td>
<td>0.08</td>
</tr>
<tr>
<td>Other trees</td>
<td>7.14</td>
<td>1.50</td>
<td>5.53</td>
<td>0.44</td>
<td>0.69</td>
<td>0.36</td>
</tr>
</tbody>
</table>
Ecuadorian Nacional - Shortest genetic distance of all South American clusters to Criollo group - both Criollo and Nacional have white beans.

Chuncho fine flavor - Chuncho aromatic diversity which is completely unmatched in other *T. cacao* varieties - fine flavor cacaos have aromatic pulp (Bertus Eskes)

Moche-Chinchipe-Marañon: role in domestication (5,000BP) - increase frequency white beans.
Chuncho La Convencion (Zhang et al unpublished)
- Shortest genetic distance of all South American clusters to Criollo group
  - both Criollo and Nacional have white beans

- Chuncho aromatic diversity which is completely unmatched in other T. cacao varieties
  - fine flavor cacaos have aromatic pulp (Bertus Eskes)

Moche-Chinchipe-Marañon: role in domestication (5,000BP) - increase frequency white beans

3-4,000BP?

Coast-Arazon contact >5,000BP

Bolivian Nacional
• 178 genotypes from Cuzco, Junin, Piura
• Flavours and aroma
• 71 SNP markers
• Cluster analysis:
  1. Discriminant Analysis of principal components
  2. Structure

K=5 → K=11
DAPC K=9

CUZCO - JUNIN

INTRODUCED

CUZCO

CUZCO

JUNIN

JUNIN

CUZCO

CUZCO

PIURA

 PIURA

CUZCO

CCN-51

INTRODUCED

DAPC K=9

CUSCO - JUNIN

CUSCO

JUNIN

CUSCO - JUNIN

chuncho

JUNIN

chuncho

PIURA

national ecuador
STRUCTURE
K=8

cluster 1
cluster 2
cluster 3
cluster 4
cluster 5
cluster 6
cluster 7
cluster 8
Hybrids
STRUCTURE

K=8

cluster 1

cluster 2

cluster 3

cluster 4

cluster 5

cluster 6

cluster 7

cluster 8

Hybrids
Origin of fine or flavour cacao in southern Peru?

- Unmatched diversity in genetic, organoleptic and morphological diversity (typical for centers of origin)
- Indications of genetic linkages between Nacional/Porcelana cacao and southern Peru (Cuzco)
- Presence of white beans in southern Peru + white bean cacao genotypes with hexamerous flowers
- Anecdotal evidence of unique use and management of cacao among local indigenous group
  - Consumption of beans (fermented and roasted) during travel
  - Management of cacao stands in “natural” forest
- But…we aren’t there yet: chloroplast markers, new genetic analyses, ethnographic work
Thank you

Evert Thomas
e.thomas@cgiar.org

www.bioversityinternational.org/subscribe

@BioversityInt