Biodiversity of herpetofauna in Central American cocoa based agroforests

Deheuvels, O.¹, ²*, Soto Quiroga, G.², Cerda, R. ², Gutierrez R. ², Andino, C. ², Molinares, B. ², Toro, J.J. ² and Somarriba, E².

¹: CIRAD, UMR System, F-34070 Montpellier, France
²: CATIE, DID, 7170, Cartago, Turrialba 30501, Costa Rica
* Corresponding author. Tel.: +506 25 58 23 44, fax: +506 25 58 20 45. E-mail address: deheuvel@catie.ac.cr / olivier.deheuvels@cirad.fr
FAOSTAT, 2009: 4.08 millions tons produced, 8.74 millions ha, 6.50 millions farmers, 95% of them are smallholders. Average world yield is 467 kg/ha/year.

Source: Clough et al. (2009)
World map of biodiversity hotspots shaded in light grey, with area of cacao production per country in dark grey. (production data 2007, FAOSTAT 2009)
NOTA: The Guinean Forests of West Africa hotspot is obscured.
Ecological Services of interest for ecologically intensive agriculture

Hypotheses:

1- Variability in vegetation structure of SAF cacao can be characterized on a structural gradient reflecting contrasting management intensity levels.

2- The cocoa productivity depends on the vegetation structure in the cocoa field.

3- The wild biodiversity found in the cocoa field is also affected by the vegetation structure.
4- The trade-offs between the productivity of the main crop and biodiversity are affected both by the vegetation structure and the species considered.
COCOA AFS Network
5 countries
6 cocoa growing areas
220 cocoa AFS
26 forest patches

MAIN STUDIES (5 countries)

CARBON CAPTURE

PROVISION of HABITAT
- Amphibians
- Reptiles
- Soil and litterfall invertebrates
- Cocoa pollinators

CALIDAD FISICA, QUIMICA y BIOLOGICA DEL SUELO

PRODUCTIVITY
- Cocoa
- Fruit and Timber Trees

DERIVATED STUDIES

C FOOTPRINT
Nicaragua

BIRDS
Nicaragua

IMPACT ON COCOA YIELD
Panama

FERTILIZATION
Nicaragua

BIOCARBON
Costa Rica

HOUSEHOLD ECONOMY
Methods

36-40 SAF cacao and 3-8 forest patches (control) in 6 central american cocoa producing areas.

Data collected on 1000 m$^2$
Plots (vegetation) and 8 x 25 m$^2$ sub-plots (animals)
Above Cocoa Trees

- Identification, Total height and dbh.
- Shade % at 1m height, in dry and rainy seasons.

Cocoa Trees

- Identification, Total height and dbh.
- N° of pods every 2 month during 2 years

Under cocoa Trees’ canopy

- % Ground cover: 10 x 1 m², 4 times a year (ligneous, grasses, mosses, ferns, litterfall)
Acumulation curves for plant species higher than 2,5m in Central American cocoa AFS
VARIABLES DISCRIMINANTES

Above cocoa trees
- Associated plant density
- Specific Richness
- Evenness
- Abundances per strata
- Proportions Trees/Palms/Musa

Cocoa trees
- Density
- Abundance per strata
- Basal area

Under Cocoa Trees
- Proportion of trees and grasses

1-canopée dense et complexe (n=6)
2-haute densité de cacaoyers (n=11)
3-haute densité de Musacées (n=10)
4-canopée complexe et peu dense (n=9)
Beta diversity of associated plants between 4 groups of cocoa-based AFS and 1 group of forest patches (control) in Talamanca (COSTA RICA)

Sørensen’s similarity coefficients calculated between four cocoa-based AFS clusters and one forest cluster (control) based on vegetation structure and produced from a sample of 36 cocoa-based AFS and 8 forest patches. Results are shown for associated plants >2.5 m height (a), reptiles (b) and amphibians (c).
Cocoa yield/ha/year and /tree in each cluster

Pods/ha/year [NS]  Pods/cocoa tree [**]

Management intensity

1  4  2  3
Methods

36-40 SAF cacao and 3-8 forest patches (control) in 6 central american cocoa producing areas.

Data collected on 1000 m² Plots (vegetation) and 8 x 25 m² sub-plots (animals)
AMPHIBIANS and REPTILES capture
REPTILES accumulation curves in COCOA AFS from 6 Central American cocoa growing regions and forest controls
AMPHIBIANS accumulation curves in COCOA AFS from 6 Central American cocoa growing regions and forest controls
Sørensen’s similarity coefficients calculated between four cocoa-based AFS clusters and one forest cluster (control) based on vegetation structure and produced from a sample of 36 cocoa-based AFS and 8 forest patches. Results are shown for reptiles (C) and amphibians (D).
AMPHIBIANS

<table>
<thead>
<tr>
<th>Species</th>
<th>PA</th>
<th>CR</th>
<th>NC</th>
<th>GN</th>
<th>GS</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caecilia volcani</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strabomantis biporcatius</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incilius campbelli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dermophis mexicanus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craugastor chac</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craugastor charadra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incilius campbelli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithobates brownorum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ptychodrya hypomykter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AMPHIBIAN species found in Central American cocoa AFS and reported on the UICN red list

- **Caecilia volcani**: Data deficient
- **Strabomantis biporcatius**: Vulnerable
- **Incilius campbelli**: Vulnerable
- **Dermophis mexicanus**: Vulnerable
- **Craugastor chac**: Vulnerable
- **Craugastor charadra**: Vulnerable
- **Incilius campbelli**: Vulnerable
- **Lithobates brownorum**: Data deficient
- **Ptychodrya hypomykter**: Endangered
Trade-off between plant diversity and cocoa yield

**Indice de diversité Shannon (H')**

**Rendement par hectare (kg de cacao marchand ha⁻¹ an⁻¹)**

Forêts

Monoculture CACAO 1191 kg ha⁻¹ an⁻¹
Trade-off between Reptile diversity and cocoa yield

**Agroforesterie cacao : durabilité et environnement – Yaoundé, Cameroun – 21-22 octobre 2012**
Trade-off between Amphibian diversity and cocoa yield
Indice de diversité Shannon ($H'$)

Rendement par hectare (kg de cacao marchand ha$^{-1}$ an$^{-1}$)

Monoculture CACAOT 1191 kg ha$^{-1}$ an$^{-1}$
Thank you

Centrolene ilex

Atelopus varius
Estimated number of REPTILE species captured on the first FOREST PLOT and accumulation rate calculated on the first 3 plots.
FORESTS

Estimated number of AMPHIBIAN species captured on the first FOREST PLOT and accumulation rate calculated on the first 3 plots.