The Assembly and Evolution of the Amazonian Biota and its Environment

Dimensions of Biodiversity US-BIOTA-São Paulo

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www.amazoniabiodiversity.org
Amazonia: vast, diverse and important

Vast
- Portions of nine nations
- Seven million square kilometers

Diverse
- Huge taxonomic/ecological diversity
- Complex and deep environmental history

Globally important
- Total forest biomass ~100 billion tons C
- 20% of atmospheric O₂
- 10% global terrestrial NPP
- 15-20% global freshwater flows
- 25 million people (2010)
- Forest cover continues to be lost
Scientific challenges and goals

- How is genetic, taxonomic, and ecological diversity distributed within Amazonia?
- What has been the evolutionary history of the Amazonian biota and how was it generated?
- What has been the history of the Amazonian aquatic and terrestrial environments?
- How has the Amazonian environment and its biota evolved together, and what have been the global effects of this evolutionary-ecological system over time?

Requires a new integrated approach
NSF-FAPESP-NASA project: broad-scale collaboration

**Brazil**
- Universidade de São Paulo
- Universidade Federal de Goiás
- Universidade Federal do Pará
- Universidade Estadual de Campinas
- Museu Paraense Emílio Goeldi
- Instituto Nacional de Pesquisas da Amazônia

**Argentina**
- CONICET-Instituto Superior de Entomologia, Tucumán

**Great Britain**
- University of Edinburgh

**Canada**
- University of Toronto

**United States**
- American Museum of Natural History
- City University New York
- Field Museum of Natural History
- Middle Tennessee State University
- Natural History Museum Los Angeles County
- New York Botanical Garden
- University of Michigan
- University of Colorado
First annual collaborator meeting
Saõ Paulo, Brazil
4-8 March 2013

1. Open public symposium on Amazonian biota and environment

2. Four days of interactive planning meetings

Collaborators
Meeting the scientific challenges calls for integrative cross-disciplinary studies

1. Characterizing Amazonian Biodiversity
   - Analysis of terrestrial diversity
   - Hierarchical endemism analysis

2. History of Amazonian taxonomic diversity
   - Phylogeny
   - Historical biogeography

3. Genetic diversity and reconstructing environmental change and stability
   - Phylogeography
   - Population demography
   - Biotic interchange

4. Amazonian paleogeography
   - Neogene paleoenvironments
   - Neogene river dynamics
   - Geochronology

5. Structural and functional diversity of ecosystems
   - Assembly of ecosystems/biomes
   - Change and resilience of functional diversity over time

6. INTEGRATION: Biotic history and Earth history
   - Tectonic/climatic drivers of diversification
   - Paleoenvironmental change

7. INTEGRATION: Evolution of diversity and environment
   - Spatial diversity analysis
   - Diversity/environmental analyses

8. INTEGRATION: Scales of environmental change
   - Environmental/ecosystem stability analyses
   - Population genetic stability analyses
   - Ecosystem spatial-temporal change
Expected data flows

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Remote sensing
- Environmental data layers
- SRTM topography (geology, abiotic)

Point-locality specimen data
- Taxonomic IDs

Remote sensing
- Environmental data layers
- DNA sequences (character data, matrices, ESTs)

Spatial diversity measures & variables
- Georeferenced specimen databases

Endemism data files
- Phylogenies, chronograms area-relationships

Gene networks/trees
- Demographic history
- Gene flow history

Spatio-temporal environmental ecosystem flows

Earth-systems GCM models & remote sensing data: C, CH4, vegetation, biomass, climate, etc.

Geological field data:
- Paleontology, stratigraphy,
- Geochronology: zircon, radiometric dating, magnetostratigraphy
Reconstructing the history of the Amazonian biota and environment: some examples of integration
Integrating phylogenetic history and paleogeography

- QUANTITATIVE DISTRIBUTION & ENDEMISM
- KEY TARGET TAXA
  - birds
  - primates
  - butterflies
  - vascular plants
- FINE TAXONOMIC SCALE
- NEXT-GEN SEQ.

Areas of endemism

- Guianan
- Napo
- Negro
- Inambari
- Xingu
- Tapajós
- Belem
- Rondônia
Phylogenetic and biogeographic patterns of *Psophia*

North Amazon/South Amazon east/west patterns

Timeline estimated by two independent methods

Ribas et al. *PRS* 2012

Leads to a predictive Amazonian paleogeography: testing alternative models
Paleogeographic model based on *Psophia*

Testable:
- by other taxa
- by geology

Ribas et al. *PRS* 2012
Integrating paleogeography and remote-sensing using SRTM

SRTM
% slope at 5 km scale
SRTM and Rio Negro paleogeography

Almeida-Filho & Miranda. 2007. 
Integrating phylogeographic (genetic) structuring with paleoclimatology & landscape modeling

P. viridis: more stable environment

P. crepitans: more unstable environment
Prescribed climate: 5ºC cooling, 20% reduction in precipitation (relative to today) and reduction in atmospheric CO₂ (200 ppmv)
Other ongoing activities

- Assembled ~500,000 digital distribution records for birds & ~80,000 primates. (Authority files: collection localities and geographical locations)

- New postdocs, grad & undergrad students on board (Brazil programs: Science without Borders; CAPES)

- Other integrative activities moving forward:
  - geology-palynology-paleoclimate
  - phylogeography-environmental modeling
  - phylogenetics-paleogeography

- Website is launched: www.amazoniabiodiversity.org