The Brazilian Barcode of Life (BrBOL) initiative and its potential to aid in biodiversity conservation

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order Carnivora
order Carnivora

Phylogeny, phylogeography, population genetics, molecular ecology, genomics
THE JAGUAR GENOME PROJECT

• Brazilian-led initiative (PUCRS, FIOCRUZ-MG, ESALQ/USP) + Sorocaba zoo and several collaborators (USA, Russia, Spain, Portugal, Ireland)

• Full sequence of the jaguar genome (84x).

• De novo assembly, de novo annotation, comparative analyses.

• Transcriptomes from multiple tissues.

• Population genomics
  • Exome sequencing for >100 wild jaguars from different regions.
  • Population structure and history, scans for selection.
Applications of DNA Barcoding in Biodiversity Conservation

1. Gathering data on components of native biodiversity;
   1.1. Baseline data (e.g. community composition and dynamics, geographic distribution, trophic interactions).
   1.2. Monitoring of biodiversity in impacted areas.

2. Gathering data on threats to native biotas.
   - e.g. invasive species, pathogens, wildlife trafficking.

3. Helping to enforce actions aimed at curbing threats to biodiversity.
   - e.g. wildlife forensic analyses.

E. Eizirik, CBOL regional mtg. Brazil, 2007
Brazil

**Area:** 8,515,767 km²
**Population:** 190,732,694

**Megadiverse country**

- Estimated to harbor ~1.8 mi spp. (10-17% of the world’s total)
  [Lewinsohn & Prado 2005]

- Known fauna:
  ~9k vertebrates (711 mammals, 1,900 birds, 732 non-avian reptiles, 973 amphibians, 3,133 continental fish, 1,376 marine fish)

Map: wikipedia.org
Brazil: newly recognized mammal species [2013-2014]

Tapirus kabomani

Inia araguaiensis

Leopardus guttulus
a) Mitochondrial DNA

Implications for DNA barcoding

Going back to a broader perspective...

**Brazilian Biomes**

- High biodiversity.

- High endemism.
  
  *(e.g. 50% of Atlantic forest amphibians are endemic)*

- High rate of habitat destruction.

Map: http://meioambiente.culturamix.com/
Atlantic Forest destruction

~10% left
- Highly fragmented

Map: SOS Mata Atlântica
Meta-barcoding of Atlantic Forest bromeliad tank waters

Aechmea gamosepala

Vriesea platynema

CPCN Pró-Mata, PUCRS, Brazil
Meta-barcoding of Atlantic Forest bromeliad tank waters
The effort towards Large-scale DNA barcoding of Brazilian biodiversity

Initial Proposal (2005):
   Beginning of the Brazilian DNA barcoding network

- **Large-scale inventory of Brazilian biodiversity**

- Multi-center project designed in 2005 to boost taxonomic research in Brazil using the DNA barcode concept as a catalyst to integrate field collections, museum-based biodiversity research, genome center networks and bioinformatics advances.

- 6 museums, 14 Centers of Molecular Biodiversity, ~300 people
Large-scale inventorying of Brazilian biodiversity (2005)

Sampling strategy

15 sites:
- 10,000 samples/site:
  - fish
  - amphibians
  - reptiles (incl. birds)
  - mammals
  - spiders
  - Leguminosae
2010 – BrBOL launched

Phase 1:
~US$ 3,000,000
2010-2014
>100 participating groups

~500 people involved

- All major Brazilian museums and natural history collections.
- Bioinformatics center
- Biomedical institution
- Agricultural research agency

The two largest museums did not have molecular biology laboratories.
- Implemented in both via funding from the BrBOL network.
### Projects

The Brazilian Barcode of Life Consortium has 11 projects:

<table>
<thead>
<tr>
<th>PROJECT ID</th>
<th>PROJECT NAME</th>
<th>GROUP LEADER</th>
<th>DESCRIPTION</th>
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<td>P.J. 01</td>
<td>Barcoding Tetrapoda: 4 sub-groups</td>
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<td>Amphibians (C. Haddad)</td>
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<td>Reptiles (H. Zaher)</td>
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<td>Birds (C. Miyaki)</td>
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<td>Mammals (E. Eizirik)</td>
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<td>P.J. 02</td>
<td>Brazilian Initiative for molecular identification of Marine Organisms</td>
<td>Madalena Cabral de Oliveira</td>
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<td>P.J. 03</td>
<td>Brazilian DNA Barcoding Initiative for Aquatic Amphibians</td>
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<td>P.J. 04</td>
<td>Vouchers Management and Institutional Capacity to Generate DNA Barcodes</td>
<td>Paulo Andreussi Bacca</td>
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<td>P.J. 05</td>
<td>Molecular Identification of Biodiversity of Terrestrial Invertebrates</td>
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<td>P.J. 06</td>
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<td>Maria Cristina Rennó Azevedo</td>
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<td>P.J. 07</td>
<td>Molecular Identification of Brazilian Fungi</td>
<td>Arlindo Seixas Sales Neto</td>
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<td>P.J. 08</td>
<td>Molecular Identification of Brazilian Parasites and Vectors</td>
<td>Fernando Araujo Moreira</td>
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<td>P.J. 09</td>
<td>DNA Barcoding of Brazilian Mollusks</td>
<td>Jorge Yu Shobu Hiroi</td>
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<td>P.J. 10</td>
<td>DNA Barcoding of Tetrapoda: Amphibians, Reptiles, Birds and Mammals</td>
<td>Eduardo Eizirik</td>
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<td>P.J. 11</td>
<td>Brazilian Network for Molecular Identification of Biodiversity</td>
<td>Obdacio de Oliveira</td>
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</table>
DNA barcoding of Brazilian tetrapods (2010-2014)

25 participating institutions

> 100 people involved

Participating labs
Mammals
Birds
Non-avian reptiles
Amphibians

4 Major Natural history collections in Brazil

French Guiana joined BrBOL
DNA barcoding of Brazilian tetrapods

Results: DNA Barcode (*COI*) library construction (2010-2015)

<table>
<thead>
<tr>
<th>Group</th>
<th>Barcoded Individuals</th>
<th>Barcoded Species</th>
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</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>5,100</td>
<td>450</td>
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<tr>
<td>Non-avian reptiles</td>
<td>2,608</td>
<td>816</td>
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<tr>
<td>Birds</td>
<td>3,508</td>
<td>1,253</td>
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<td>Mammals</td>
<td>2,122</td>
<td>344</td>
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<td><strong>Total</strong></td>
<td><strong>13,338</strong></td>
<td><strong>2,863</strong></td>
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Geographic distribution of amphibian barcodes – BrBOL
(M. Lyra, C. Haddad)

Total 5100 ind – 4750 in BOLD (~450 species)
DNA barcoding of Atlantic Forest amphibians
(M. Lyra, C. Haddad)

~3800 inds/vouchers

- 386 species
  (71% of the known species).

- 59/63 genera
Geographic distribution of mammal DNA barcodes
Geographic distribution of mammal DNA barcodes
DNA barcoding of speciose and taxonomically complex groups

Development of mini-barcodes for the identification of carnivores from fecal samples

Dietary analyses of wild cats using DNA barcodes of prey items

F. Tirelli, H. Figueiró, T. Trigo, M. Appel
Dietary analyses of wild cats using DNA barcodes of prey items
Dietary analyses of wild cats using DNA barcodes of prey items

Leopardus guttulus

Akodon azarae
Wildlife Forensics

- Proof of concept studies by various university laboratories.
- DNA barcoding now routinely used by the Brazilian Federal Police.

Well-publicized case: Man arrested in 2003 with 58 eggs packed around his body. DNA barcoding used to identify the source species.
Wildlife Forensics

DNA Barcoding Identifies Illegal Parrot Trade

Priscila F. M. Gonçalves, Adriana R. Oliveira-Marques, Tania E. Matsumoto, and Cristina Y. Miyaki

Journal of Heredity, 2015, 560–564
DNA barcoding in Brazil - Perspectives

**Good news:**
1. We got started and scratched the surface
2. An unprecedented community of biodiversity scientists has been assembled and integrated in Brazil.
3. There is capacity in the country to move forward.

**Challenges ahead:**
1. Securing continuous, large-scale funding.
2. Improving governance and organizational structure.
3. Scaling up and speeding up to tackle the magnitude of the task and the pace of habitat loss in the country.
Acknowledgments

BrBOL

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Bromeliad meta-barcoding

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