Beyond species composition: a functional and ecological perspective on plant communities in inselbergs

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Inselbergs

Inselbergs are geologically-ancient, nutrient-impoverished granitic and gneiss monoliths that rise sharply above the lowland surrounding forests.
Inselbergs are good models for testing ecological, biogeographical and evolutionary hypotheses.
Main threats to inselberg flora

- Quarrying
- Land degradation
- Biological invasion
- Trampling
Predicting Extinction Risk of Brazilian Atlantic Forest Angiosperms

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All species
T = 6.41%
N = 6929

AREA OF OCCUPANCY
p<0.001, y²=269, df=1

> 2,000 km²
T = 3.96%
N = 5511

< 2,000 km²
T = 15.94%
N = 1418

GROWTH FORM
p<0.001, y²=66, df=7

Other forms
T = 3.46%
N = 5200

Epiphyte
T = 12.22%
N = 311

Vegetation Type
p<0.05, y²=6, df=6

Other types
T = 10.91%
N = 1321

Rocky outcrops
T = 29.99%
N = 97

VEGETATION TYPE
p<0.001, y²=40, df=5

Grasslands, HG
T = 2.23%
N = 2779

Rest, OF, SF
T = 4.59%
N = 2311

VEGETATION TYPE
p<0.01, y²=13, df=2

> 20,000 km²
T = 1.87%
N = 2459

< 20,000 km²
T = 5.90%
N = 320

OF, SF
T = 4.11%
N = 2116

Restinga
T = 9.74%
N = 195

OOO
p<0.01, y²=13, df=2

LOW
EXTINCTION RISK

HIGH
The harsh environmental conditions of inselbergs are markedly different from those of surrounding vegetation, and are thought to be key determinants of plant community structure in these rocky habitats.

Functional traits insights to understand how communities respond to changing environmental conditions
Study sites

Vale do Mucuri (MG) and Itacoatiara (RJ)

78 species in 93 patches
We evaluated the importance of ecological strategies in different vegetation patches on the inselberg.

Particular environmental characteristics should filter distinct functional strategies in each patch type.
Habitats

- Shallow depressions: 76 spp.
- Crevices: 17 spp.
Monocot mats

14 spp.

Stehmann, JR

Viana, P.L.
Ephemeral humid vegetation

10 spp.

Epilithic

15 spp.

Stehmann, JR
Trait sampling

New handbook for standardised measurement of plant functional traits worldwide

EVIDENCE FOR THE EXISTENCE OF THREE PRIMARY STRATEGIES IN PLANTS AND ITS RELEVANCE TO ECOLOGICAL AND EVOLUTIONARY THEORY

J. P. GRIME

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TABLE 1

SUGGESTED BASIS FOR THE EVOLUTION OF THREE STRATEGIES IN VASCULAR PLANTS

<table>
<thead>
<tr>
<th>INTENSITY OF DISTURBANCE</th>
<th>INTENSITY OF STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>Competitive strategy</td>
</tr>
<tr>
<td>High</td>
<td>Ruderal strategy</td>
</tr>
</tbody>
</table>
M. repens funcionaionally distinct from the resident community

Analyses at species- and patch-level indicated a dominance of stress-tolerance and competitive strategies.
We tested for a connection between the patch structure and plant functional traits.

If filters structure the community, then a strong trait-environment relationship should be expected.
Environmental drivers

- Slope
- Area (ellipse)
- Soil depth
- Invaded or not
Combining the fourth-corner and the RLQ methods for assessing trait responses to environmental variation

Stéphane Dray, Philippe Choler, Sylvain Dolédec, Pedro R. Peres-Neto, Wilfried Thuiller, Sandrine Pavoine, and Cajo J. F. ter Braak

1. Matrix L – species per sample
2. Matrix R – environmental drivers per sample
3. Matriz Q – species traits

→ RLQ : summarizes the multivariate association among the three matrices

→ Fourth corner: tests pairwise relationships between functional traits and environmental drivers
Most functional traits significantly correlated with at least one environmental driver, highlighting their role in structuring plant communities in this heterogeneous environment.
Fourth-corner analysis was consistent with RLQ analysis.
We compared the variation in functional traits between native and an exotic invasive species to check whether they show converging or diverging functional traits.

We expected invasive species to have particular ecological strategies, which could give them some advantage over native species.
Given the spatially heterogeneous resources, some patch types were more invasive-prone than others.
Melinis repens show traits related to ruderality...

<table>
<thead>
<tr>
<th></th>
<th>Invaded patches</th>
<th>M. repens</th>
<th>One-sample t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruderalism (%)</td>
<td>4.4 ± 1.7</td>
<td>32.2</td>
<td>−13.792**</td>
</tr>
<tr>
<td>Specific leaf area (mm² mg⁻¹)</td>
<td>11.9 ± 0.7</td>
<td>23.1</td>
<td>−10.512**</td>
</tr>
<tr>
<td>Leaf width (mm)</td>
<td>38.7 ± 6.3</td>
<td>4.6</td>
<td>8.052**</td>
</tr>
<tr>
<td>Leaf area (cm²)</td>
<td>110.7 ± 25.3</td>
<td>7.3</td>
<td>5.835**</td>
</tr>
<tr>
<td>Competitiveness (%)</td>
<td>51.6 ± 3.8</td>
<td>37.5</td>
<td>3.744*</td>
</tr>
<tr>
<td>Stress-tolerance (%)</td>
<td>44.0 ± 4.2</td>
<td>30.3</td>
<td>3.291*</td>
</tr>
<tr>
<td>Seed mass (mg)</td>
<td>5.2 ± 2.0</td>
<td>0.2</td>
<td>3.170*</td>
</tr>
<tr>
<td>Canopy height (mm)</td>
<td>824.3 ± 111.8</td>
<td>441.5</td>
<td>2.368</td>
</tr>
<tr>
<td>Leaf toughness (KgF)</td>
<td>5.8 ± 0.8</td>
<td>5.1</td>
<td>−1.043</td>
</tr>
</tbody>
</table>

Significantly different at * p < 0.01; ** p < 0.001
...and decreased B-diversity in invaded patches
Synthesis
Functional ecology as a missing link for conservation of a resource-limited flora in the Atlantic forest

Luiza F. A. de Paula¹ · Daniel Negreiros² · Luísa O. Azevedo¹ · Renato L. Fernandes¹ · João Renato Stehmann¹ · Fernando A. O. Silveira¹
Different inselbergs harbour different species, but share the same traits.
We tested the **stress-dominance hypothesis**: a model of community assembly predicting that the relative importance of environmental filtering increases and competition decreases along a gradient of increasing environmental stress.
Patch size

Diversity

Stress tolerance trait
Competitive dominance trait
Competition-tolerance tradeoff trait
Resource use trait

Low Stress High

Competition

Environmental filtering
SHORT COMMUNICATION

Positive association between *Bromelia balansae* (Bromeliaceae) and tree seedlings on rocky outcrops of Atlantic forest

Fernando Souza Rocha*,†, Leandro da Silva Duarte† and Jorge Luiz Waechter†
Conclusions

Inselbergs are heterogeneous environments → islands within islands

Functional traits play a key role in structuring plant communities in inselbergs

Our data contribute to the understanding of historical and contemporary factors that shape plant communities in inselbergs and will be helpful to predict how resource-limited environments will respond to future global change drivers
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