‘Islands in the Sky’
‘Islands in the Sky’ - Tepuis

- Guayana Shield centered in southern Venezuela
- $1.2 \times 10^6 \text{ m}^2$
- sandstone table mountains of Roraima Formation

Autana, 1300 m
‘Islands in the Sky’ - Tepuis

- Roraima Formation - Precambrian, highly leached sandy marine sediments laid down 1.5 - 1.8 billions years ago

- Roraima Formation uplifted during formation of Atlantic in Cretaceous

- tepuis formed with erosion of major river systems (Orinoco) – vicariance?

- tepuis are resistant (quartzite) mesas
Autana, 1300 m
Roraima, 2723 m
Kukenán, 2650 m
Neblina, 3014 m
‘Islands in the Sky’ - Tepuis

- tepuis basis for Sir Arthur Conan Doyle’s “The Lost World”
- actually home to one of the world’s largest set of plant “carnivores”

Heliamphora - sun pitcher
‘Islands in the Sky’ - Tepuis

- tepuis basis for opening scene of *Arachnophobia*

*Canaima National Park*
‘Islands in the Sky’ - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation portion over 1500 m
‘Islands in the Sky’ - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation portion over 1500 m
- Distinctive biota

Tepui vireo
Redbanded fruiteater
Tepui manakin
Rana
Asteraceae
‘Islands in the Sky’ - Tepuis

- Pantepui - biogeographic province proposed by the Phelps for high elevation portion over 1500 m

- characterized by a combination of extreme conditions: cool weather, heavy rainfalls, dense clouds, strong winds, high solar radiation, and extremely infertile substrates
Tepui Flora

- *Heliamphora* (Sarraceniaceae) - sun pitcher
Do the tepuis function as islands?

Ricarda Riina
Tepui Flora

- Pantepui - island like species/area relationship

Riki Olivares - M.S. thesis

![Graph showing the relationship between log number of species and log summit area with a linear trend and p-value of < 0.0001]
Tepui Flora

- Pantepui - 40% of species restricted to pantepui

Elevation ranges of Pantepui species
(spp above 1500 m)

Lower elevation ranges for Pantepui species (m)

- 0--599: 25%
- 600--999: 18%
- 1000--1499: 17%
- 1500--3000: 40%
# Tepui Flora

- **Pantepui - island like endemism**

## Overall plant richness and endemism

<table>
<thead>
<tr>
<th></th>
<th>Pantepui taxa</th>
<th>Shield endemics</th>
<th>Pantepui endemics</th>
<th>Single tepui endemics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Families</strong></td>
<td>156</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Genera</strong></td>
<td>626</td>
<td>80</td>
<td>23 (4%)</td>
<td>13 (2%)</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td>2447</td>
<td>1517</td>
<td>1034 (42%)</td>
<td>617 (25%)</td>
</tr>
</tbody>
</table>

Riki Olivares - M.S. thesis
Tepui Flora

- Floristic relationships among tepuis
- Is there a biogeographical pattern?
  - vicariance formed by river erosion?

Vicki Funk - Smithsonian
Guayana Shield - pantepui area

eastern tepuis

western tepuis
Tepui Flora

Cluster Analysis based on floristic composition
DCA Ordination based on floristic composition
basically congruent with cluster analysis
• positive significant ($P = 0.001$) correlation between the floristic distance matrix and the among-tepuis geographic distance matrix (Mantel Test)
Tepui Flora

Do the tepuis exhibit adaptive radiations?

Tom Givnish
Adaptive Radiation in *Brocchinia*

Nutrient capture evolution in *Brocchinia*

- Non-impounding, root nutrient uptake
- Tank epiphytism (saprophytism)
- N2 fixing blue green bacteria association
- Ant-fed myrmecophory
- Carnivory
Adaptive Radiation in *Brocchinia*

Nutrient capture evolution in *Brocchinia*

**H₂O impounding**
- B. prismatica
- B. micrantha
- B. steyermarkii
- B. acuminata

**Ant fed**
- B. gilmartini
- B. hechtiiodes
- B. tatei
- B. reducta

**Blue-green bacterial N₂ fixation**
- B. melanacra N
- B. vestita
- B. cowanii
- B. maguirei N
- B. melanacra D
- B. amazonica
- B. maguirei AUT
- B. paniculata

**Carnivory**
Adaptive Radiation in *Brocchinia*

- lowlands to nutrient poor highlands of Guayana Shield
- $\text{H}_2\text{O}$ impounding “tank” are pre-adaptations to carnivory, blue-green bacteria symbiosis, ant-fed mutualism
‘Islands in the Sky’ - Paramo, Afroalpine
‘Islands in the Sky’ - Paramo, Afroalpine

- convergent biome types across high elevation areas of the tropics
- depending on elevation, often occur as ‘islands’

![Diagram showing different elevation zones and their corresponding biomes.](image)
‘Islands in the Sky’ - Paramo, Afroalpine

- South American *paramo* and East African *afroalpine* (‘Ethiopian’) best studied floristically as islands.
‘Islands in the Sky’ - Paramo, Afroalpine

- ecology is harsh and unvarying: ‘winter by night, summer by day’
‘Islands in the Sky’ - Paramo, Afroalpine

- Convergent life forms occur in both areas as a response to these ecological conditions

*Hypericum* (sclerophyll)

*Erica* (sclerophyll)

*Viola* (cushion)

*Acaena* (rosette)

tussock grass
‘Islands in the Sky’ - Paramo, Afroalpine

- Convergent life forms occur in both areas as a response to these ecological conditions

**Afroalpine**

![Diagram of plant life forms](image)

*Figure 3. The five most important life forms of the afroalpine belt. A. giant rosette plant, B. tussock grass, C. acaulescent rosette plant, D. cushion plant, E. sclerophyllous shrub (modified from Hedberg, 1964a).*

**Dendrosenecio (Asteraceae)**

**Lobelia (Lobeliaceae)**
‘Islands in the Sky’ - Paramo, Afroalpine

- Convergent life forms occur in both areas as a response to these ecological conditions

*Figure 3. The five most important life forms of the afroalpine belt. A. giant rosette plant, B. tussock grass, C. acaulescent rosette plant, D. cushion plant, E. sclerophyllous shrub (modified from Hedberg, 1964a).*

*Puya (Bromeliaceae)*

*Espeletia (Asteraceae)*
Radiation in Andean *Puya* (Bromeliaceae)

Rachel Schmidt Jabaily

*Puya raimondii*, Ancash, Peru
Radiation in Andean *Puya* (Bromeliaceae)

Direction of latitudinal and elevation shifts?
Radiation in Andean *Puya* (Bromeliaceae)

“mapping” on latitude & elevation on DNA tree

Jabaily & Sytsma 2013
Radiation in Andean *Puya* (Bromeliaceae)

Relative rates of movements in latitude and elevation

*Jabaily&Sytisma 2013*
‘Islands in the Sky’ - Paramo, Afroalpine

- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae)
‘Islands in the Sky’ - Paramo, Afroalpine

- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae) **Which pattern?**

1. Inter-island dispersal followed by elevation shifts
2. Multiple dispersals from similar elevations

8 species adapted to 4 life zones (in color)

*Mt. Kenya*

*Eric Knox*
‘Islands in the Sky’ - Paramo, Afroalpine

- Biogeography of afroalpine flora – adaptive radiation of *Dendrosenecio* (Asteraceae) Which pattern?

- Convergence of species adapted to similar elevations!

1. Inter-island dispersal followed by elevation shifts

2. Multiple dispersals from similar elevations

Phylogeny superimposed on biogeography