Lecture 11

Habitat Islands and Summary of Course

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Outline

1. Habitat islands within continents

2. The natural laboratory paradigm summarized

3. Topics we did not get to

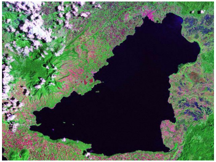
Habitat islands

- **Habitat islands** are areas within continents that are surrounded by a “sea” of a markedly different environment.
  - Lakes – the reverse image of a real island.
  - Mountaintops – areas of temperate or alpine climate, within regions of warmer climates (e.g., tropical highlands).
  - Caves.
- Habitat islands often share similar physical characteristics oceanic islands– small area, isolation and (relatively) young age.
- Although not geographically isolated, the significant differences in environmental conditions may prevent species from the surrounding region from successfully establishing themselves within the habitat island.
- Consequently, many species arrive by long-distance dispersal from distant regions that share a similar environment with the habitat island.
- For example, many species of tropical highlands have originally arrived from temperate regions.

Lakes

Lake Lanao in the Philippines.

- 18 endemic species of cyprinid fish (barbs).
- 41 endemic species of freshwater crabs.
- Most of them are probably extinct nowadays, because of overfishing, water pollution etc.

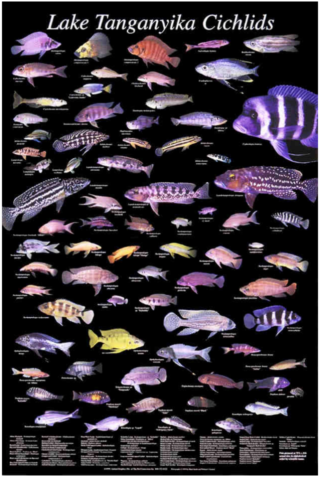


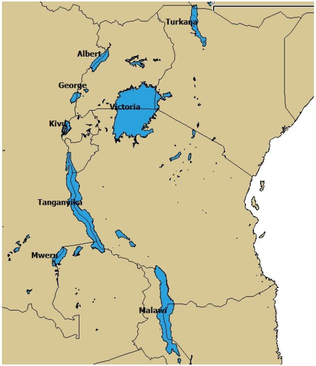


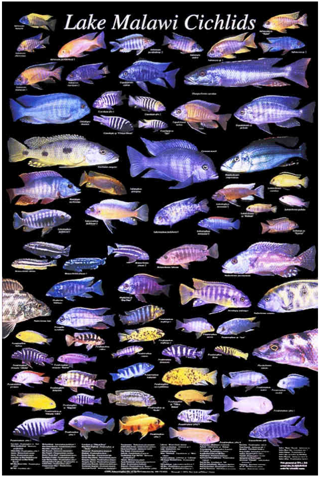
Lakes

Cichlids of the Great African Lakes.

- Remarkable and independent adaptive radiations in Lake Victoria, Lake Tanganyika and Lake Malawi.



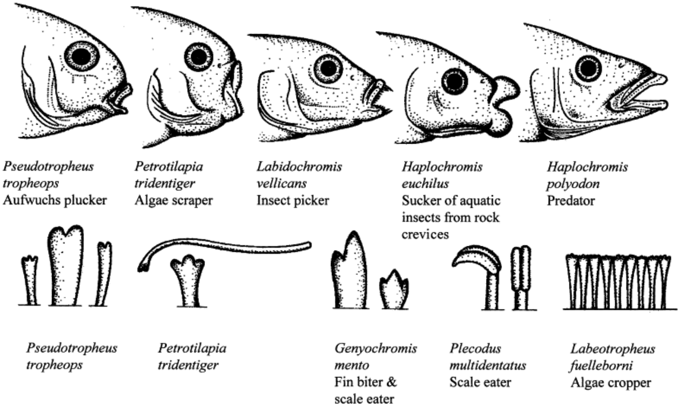




Lakes

Cichlid radiation of the Great African Lakes is **adaptive**.

- Associated with feeding behavior and niche.
- Consequently, we observe great variation in the morphology of jaws and other mouth parts.
- As well as great variation in total body size.



Mountaintops

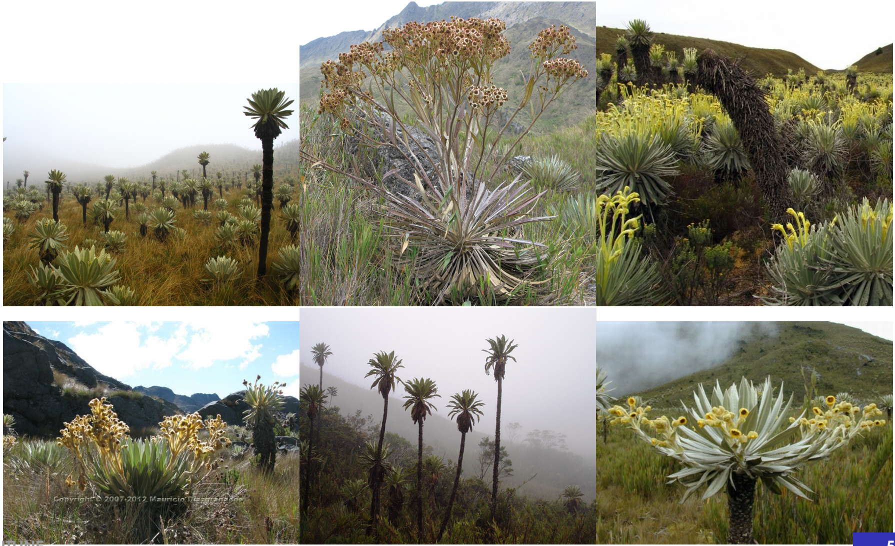
African equatorial highlands – Mt. Kenya, Mt. Kilimanjaro, etc.

- Species of *Dendrosenecio* as an example.
- Again, tree-like descendants of an ancestral herbaceous species of *Senecio* (again, family Asteracae).
- *Senecio* are common in temperate and Mediterranean regions, but not in tropical regions near the equator
  ⇒ reached equatorial regions via long-distance dispersal.
- Once on the equatorial highlands, they evolved to become tree-like – i.e., insular woodiness.

Mountaintops

South American equatorial highlands

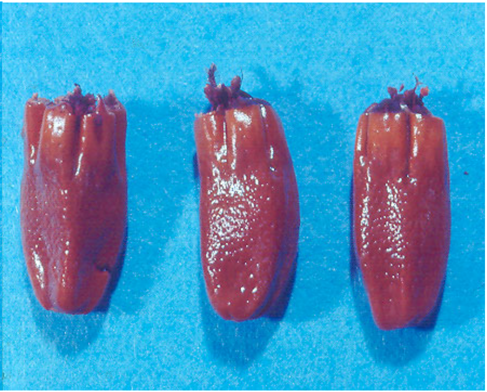
- Adaptive radiation in *Espeletia*.



Mountaintops

Darwinia **in the Stirling mountain range of southwest Australia.**

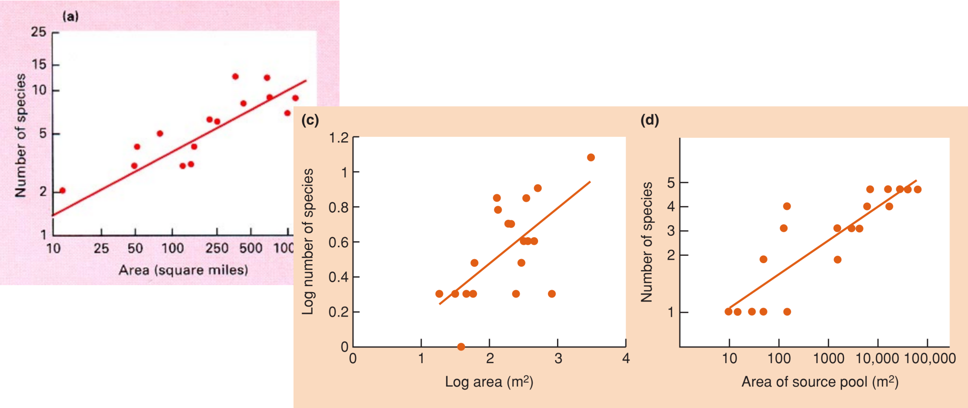
- Endemism – many species are endemic to only one or two peaks.
- Loss of dispersal ability – seed gigantism and loss of dispersal structures.

Species-area relations of habitat islands

Habitat islands have steep SARs, like we find for oceanic islands.

Examples: **(a)** Boreal mammals on mountaintops; **(c)** Bats in caves in Mexico; **(d)** Fish in desert pools in Australia;



Species-area relations of habitat islands

Comparison of SAR slopes between mainland and oceanic/habitat islands

Table 21.1 Values of the slope *z*, of species–area curves ($\log S = \log C + z \log A$, where *S* is species richness, *A* is area and *C* is a constant giving the number of species when *A* has a value of 1), for arbitrary areas of mainland, oceanic islands and habitat islands. (After Preston, 1962; May, 1975b; Gorman, 1979; Browne, 1981; Matter *et al*., 2002; Barrett *et al*., 2003; Storch *et al*., 2003.)

Taxonomic group	*Location*	z
Arbitrary areas of mainland		
Birds	Central Europe	0.09
Flowering plants	England	0.10
Birds	Neoarctic	0.12
Savanna vegetation	Brazil	0.14
Land plants	Britain	0.16
Birds	Neotropics	0.16
Oceanic islands		
Birds	New Zealand islands	0.18
Lizards	Californian islands	0.20
Birds	West Indies	0.24
Birds	East Indies	0.28
Birds	East Central Pacific	0.30
Ants	Melanesia	0.30
Land plants	Galápagos	0.31
Beetles	West Indies	0.34
Mammals	Scandinavian islands	0.35
Habitat islands		
Zooplankton (lakes)	New York State	0.17
Snails (lakes)	New York State	0.23
Fish (lakes)	New York State	0.24
Birds (Paramo vegetation)	Andes	0.29
Mammals (mountains)	Great Basin, USA	0.43
Terrestrial invertebrates (caves)	West Virginia	0.72

Slopes for oceanic and habitat islands are similar, and differ markedly from slopes of mainland areas.

Habitat islands

To summarize:

- 'Habitat islands' exhibit many of the phenomena that we encounter on real islands:
  - Arrival through long-distance dispersal.
  - Species poverty and Disharmony.
  - High endemism.
  - Adaptive radiation.
  - Loss of dispersal ability.
  - Insular woodiness.
  - Steep species-area relations.
- By comparing these habitats within continents to oceanic islands, we can gain an understanding of the ecological and evolutionary processes that determine biodiversity in those habitats.
- As well as bring a wider range of phenomena under the same theoretical/conceptual framework.

Outline

1. Habitat islands within continents
2. The natural laboratory paradigm summarized
3. Topics we did not get to

Biogeography – the study of species diversity and distributions

- Ecology → Biogeography:
  The study of biodiversity (מגוון ביולוגי) and geographic distributions (תפוצה).

- A science mainly based on observations and comparative methodology, rather than experiments.
- ⇒ Islands provide the natural laboratory where "natrual experiments" have been repeated thousands of times.

- A historical science – what we observe today is a snapshot in time – a result of historical events and "accidents", as well as the general principles and "forces" that the science aims to identify.

- Other historical sciences: History, Archeology, Geology, Astronomy, Cosmology, Philology, Paleontology, etc.

The natural laboratory paradigm

- Small area and discrete.
- "Simple" biotas.
- Numerous and varied – Repetitions of ecological and evolutionary "experiments".
- "Accelerated time" – both geologically and evolutionarily.
- "Telescoping" of environmental variability.

. . . when we have mastered the difficulties presented by the peculiarities of island life we shall find it comparatively easy to deal with the more complex and less clearly defined problems of continental distribution. . .

Alfred Russell Wallace, Island Life, 1902

The natural laboratory paradigm in light of island physics

1. Small area and discrete.
2. “Simple” biotas.
3. **Numerous and varied.**
   Same processes created thousands of islands worldwide in different circumstances – Different latitudes, different elevations, high vs. low, as single islands or in island groups, different ages, etc.
4. **“Accelerated time”.**
   Geological lifecycle of oceanic islands – on the order of 10 million years; Most are only few millions of years old or less (e.g., Hawaii).
5. **“Telescoping” of environmental variability.**
   On the same **high** island, cloud forests and deserts – very humid vs. very dry environments, elevation zones.

Summary of insular evolution

In light of the natural laboratory paradigm

- Adaptive radiation, Nonadaptive radiation, Woodiness, Loss of dispersal ability, Flightlessness, Gigantism and Dwarfism, etc. also occur on continents.
- For example, the radiation of mammals following the extinction of dinosaurs (creating disharmony and empty niches on a global scale), or evolution of trees on continents.
- However, on continents these are either rare events (adaptive radiation), or otherwise evolution occurs much more slowly.

Summary of insular evolution

In light of the natural laboratory paradigm

- **Numerous, small and discrete geographical units** – Isolation on a large number of islands have allowed for evolutionary trends to occur independently again and again in many different circumstances and in many different groups and original immigrants (e.g., flightlessness in rails occurred independently on many islands).

- **"Simple" biotas** – Species poverty and disharmony make these evolutionary phenomena exceptionally clear on islands (compared to the more complex biotas on continents).

Summary of insular evolution

In light of the natural laboratory paradigm

- **“Accelerated time”** – Relative recentness of these evolutionary changes have allowed for survival of intermediate forms and most member species of adaptive radiations (e.g., herbs, shrubs and trees evolving from same immigrant species), and ancestor species on continents for comparison.

- **“Telescoping” of environmental variability** – allows repeatedly to connect certain ecological circumstances with certain evolutionary trends (e.g., ecological release leading to flightlessness; stable habitats leading to woodiness).

Summary of insular evolution

In light of the natural laboratory paradigm

1. $\Rightarrow$ Allow for general conclusions that also apply to evolution on continents.
2. Teach us about the role of ecology, history and chance events in evolution of life on earth, in general.
3. Island studies have contributed again and again to development of theories in evolutionary biology and ecology, from before Darwin's time until today.

Summary of theory of island biogeography

- Was developed and applied originally to understanding the dynamics of biodiversity (species number) on continental islands – e.g., the Karakatau succession.
- Provides a mathematical and graphical model for effects of immigration and extinction ⇒ Provides predictions about equilibrium species number and turnover rates.
- Successfully applied to understanding SAR patterns in continents and in islands. But also to understanding biodiversity patterns within continents and to nature conservation – "habitat islands".
- This is yet another example of how island-related studies have lead to advances in ecology and evolutionary biology, in general.

The natural laboratory paradigm summarized

- Finally, we have seen how the majority of recent extinctions (so far) have occurred in island species
$\Rightarrow$ The greater damage to island biotas has raised awareness to human impact on the environment.

To summarize the course:

1. Island environments and biotas helped in understanding of general patterns and principles of ecology and evolution – e.g., species-area relations and other biodiversity patterns, origin (formation) of species, adaptive radiation and other evolutionary trends , etc.

2. Such principles and theories can then be applied also to other situations – e.g., adaptive radiations in the history of life on earth in general, or conservation efforts on continents.

Outline

Additional interesting island topics

1. Repeated "natural experiments" in human societies on islands – successes and failures.

   The book *Collapse* by Jared Diamond – chapters on Polynesian colonization of pacific ocean islands, and Viking colonization of Iceland and Greenland.