Lecture 5

Biodiversity on Islands

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Outline

Long distance dispersal to islands

- Migration to oceanic islands is via **long-distance dispersal** (הפצה ארוכת טווח).
- Governed by probability.
- Means of dispersal identified by Carlquist (1974):
  - Air flotation – very small seeds, insects, spiderlings etc.
  - Flight and island hopping – birds.
  - Birds – seeds/eggs (e.g., of insects or landsnails)/individuals attached to feathers, in mud on feet, or carried internally (ingested seeds).
  - Oceanic drift / sea flotation – resistance to seawater; e.g., coconut.
  - Rafting – seeds and animals resistant to desiccation (e.g., lizards, or landsnails).
- "Stepping stones" – islands in a chain or ancient, now vanished, islands – may have aided dispersal to remote islands.

Examples of long distance dispersal in plants

Air flotation – carried by wind, storms etc. (Or in mud on bird feet.)

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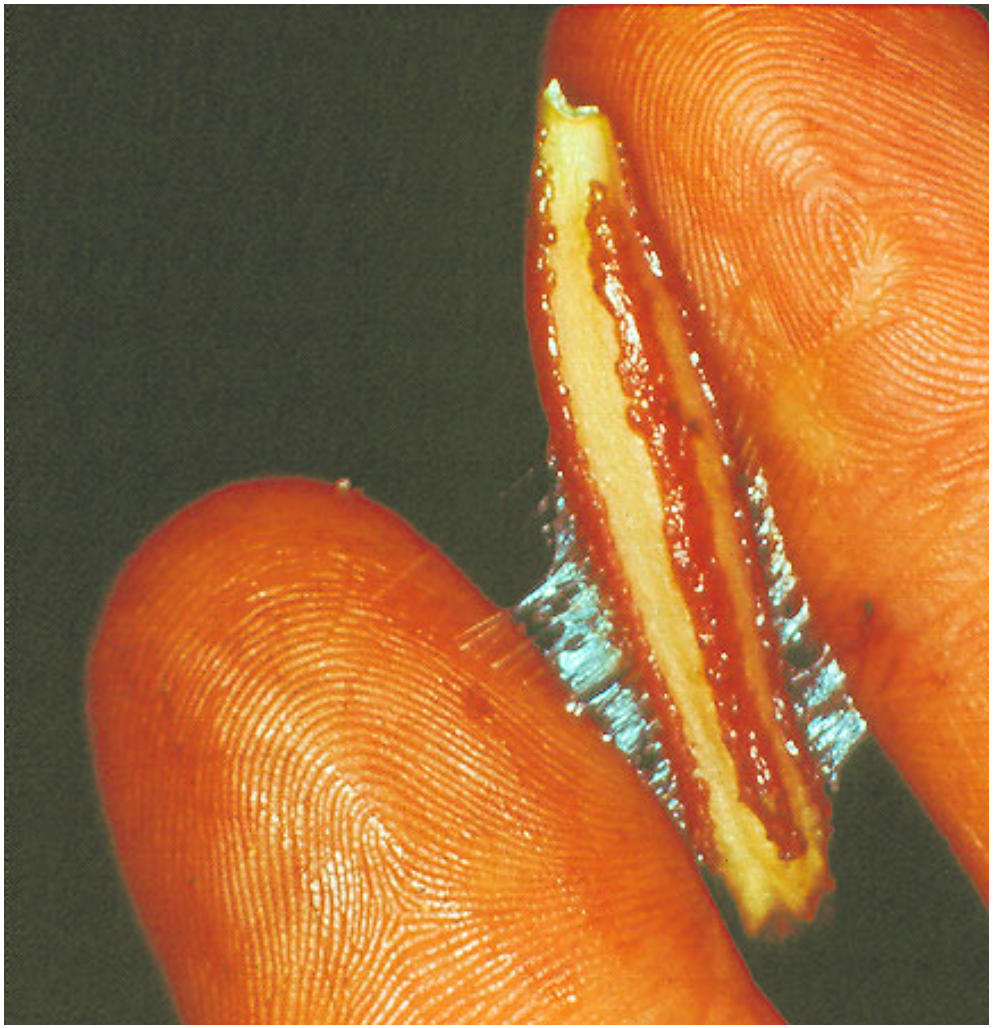
Birds, carried externally – mechanical or chemical attachment to feathers.



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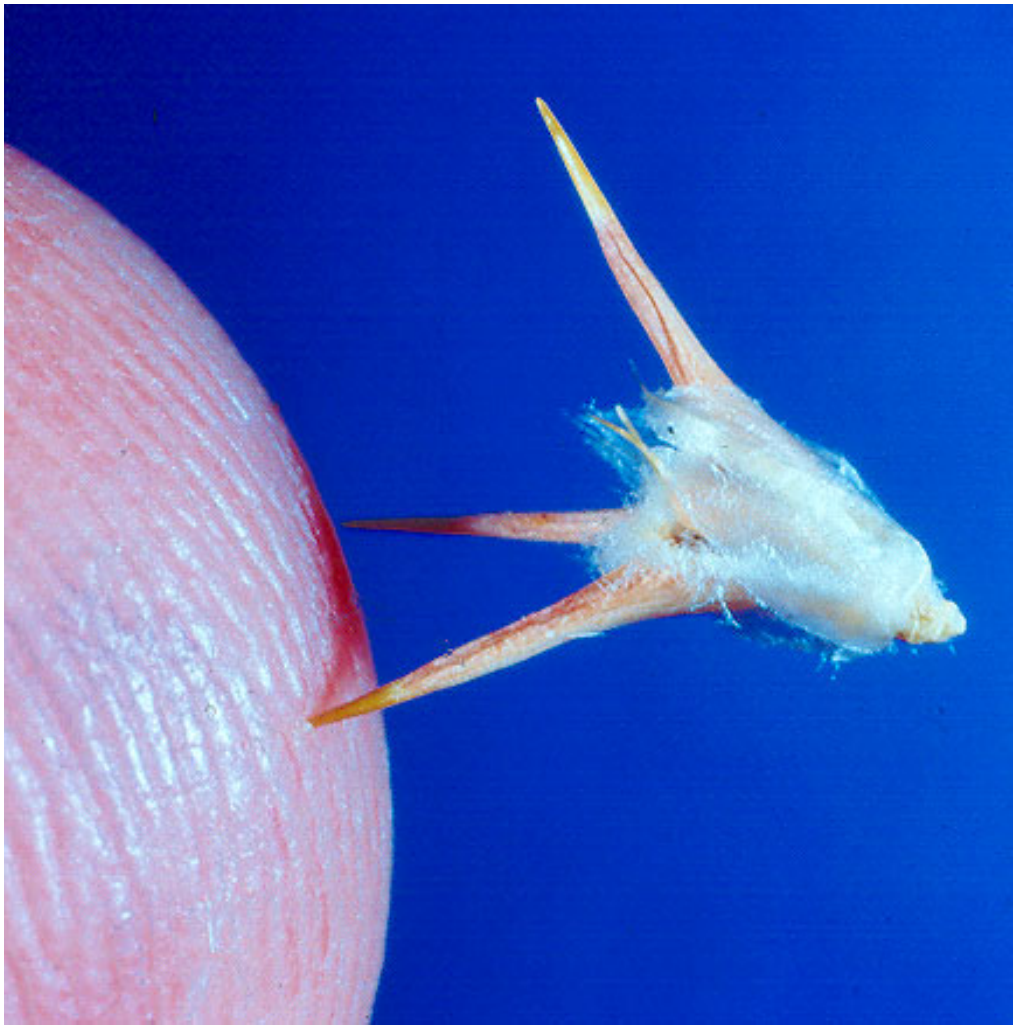

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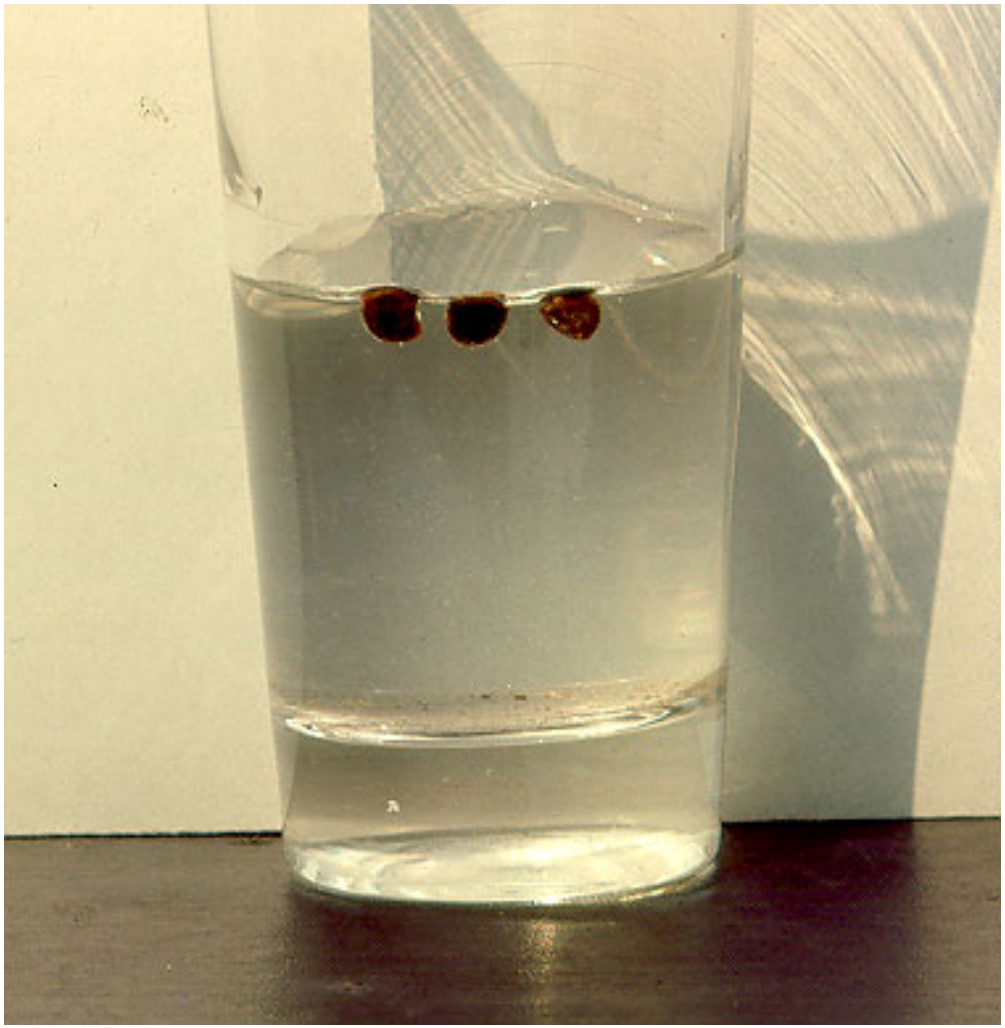
Sea flotation

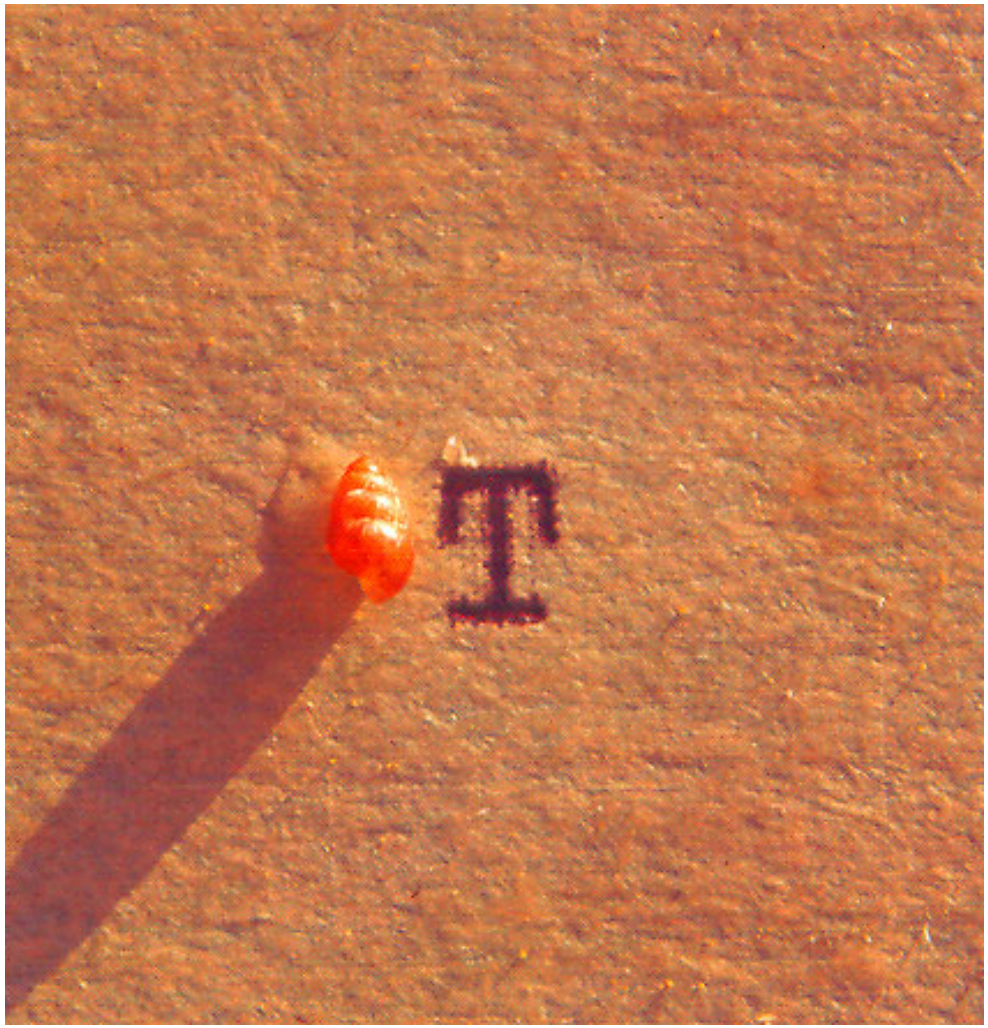


Examples of long distance dispersal in plants

Birds, internally – fruit consumed, seed carried internally to island.

Examples of long distance dispersal in plants

Last example of a landsnail, presumably also through attachment to bird feathers.



Long distance dispersal to islands

1. Some groups of animals and plants are more suited to long distance dispersal than others.

2. Actual arrival on island is ultimately a **probabilistic** event.

- " A means of transport does not need to be frequent to be operative. " (Carlquist 1974, p.69)
- " . . . occasional means of transport having been largely efficient in the long course of time, . . . " (Darwin 1859 1974, p.384)
- ⇒ Many different ways (some very strange, bizarre and improbable), by which to arrive on oceanic islands.
- ⇒ Over long geological/evolutionary time even a rare event **may** happen once or twice (or not – probabilistic occurrence).

Establishment on islands

- Not enough to arrive on island (via long-distance dispersal).
- Need to succeed in growing, reproducing and establishing a stable resident population.
- Establishment success is another filter operating after dispersal success.
- **Examples:**
  - Abiotic and biotic conditions for growth and reproduction.
  - For obligate sexual organisms – several migrants arriving (more or less) together so one can find mates (unless pregnant female arrives alone).
  - Predators – require presence of prey.
- More on that next week!

Outline

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.

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- 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.

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- 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.
- **Biodiversity of what? Geographic distribution of what?**

Species concept: a practical definition

- **Species** (מין) – A group of organisms that resemble each other in morphology, anatomy, ecology, behavior etc. and are distinct enough from other such groups.
- **Biota** – the collection of all organisms / species that inhabit a certain geographical unit.
- Biota = Fauna + Flora + . . .
- **Biodiversity** (מגוון ביולוגי) – the diversity of the biota (e.g., species number or richness).
- **Growth form** (צורת חיים) – especially for plants; herb, shrub, tree etc.

The tree of life – Taxonomy in a nutshell

Organisms are classified and named in a **hierarchical** fashion – representing both phenotypic similarity and common descent (common evolutionary history) within groups – **taxon / taxa**.

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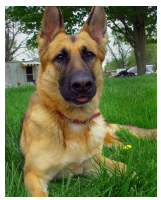
מין **Species:**  ***Canis lupus***

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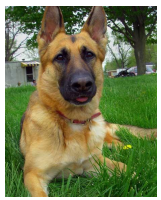
מין **Species:**  *Canis lupus*

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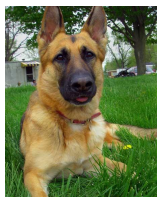
מין **Species:**  ***Canis lupus*** *Canis mesomelas*  . . .

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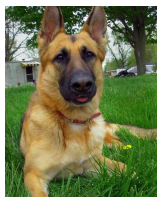
מין **Species:**  ***Canis lupus*** *Canis mesomelas*  . . .

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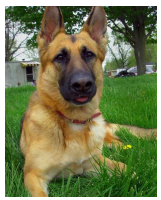
מין **Species:**  ***Canis lupus*** *Canis mesomelas*  . . .

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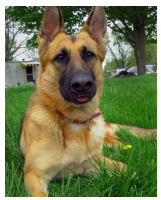
מין **Species:**  ***Canis lupus*** *Canis mesomelas* . . .

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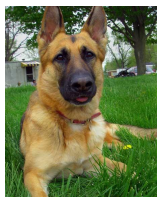
מין **Species:**  ***Canis lupus*** *Canis mesomelas*  . . .

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מערכה **Phylum:** **Chordata** Arthropoda Mollusca …

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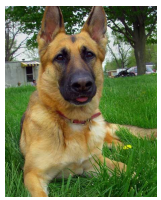

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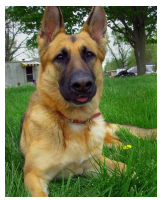


Subspecies, Breed, Variant, Population, Growth form …

Biogeography – the study of species diversity and distributions

- **Biodiversity of what? Geographic distribution of what?**
- **In examples that I provide:**
  1. Species
  2. Genera
  3. Families
  4. Subspecies, varieties, growth forms.
- An individual/seed/egg arriving at an island has the potential to contribute to biodiversity on this island, at all levels.

Biogeographic realms

Islands may gain immigrants from different realms!

Outline

Island biology in a (coco)nutshell

Island Physics

- Isolation
- Small area
- Young age

Island Biodiversity

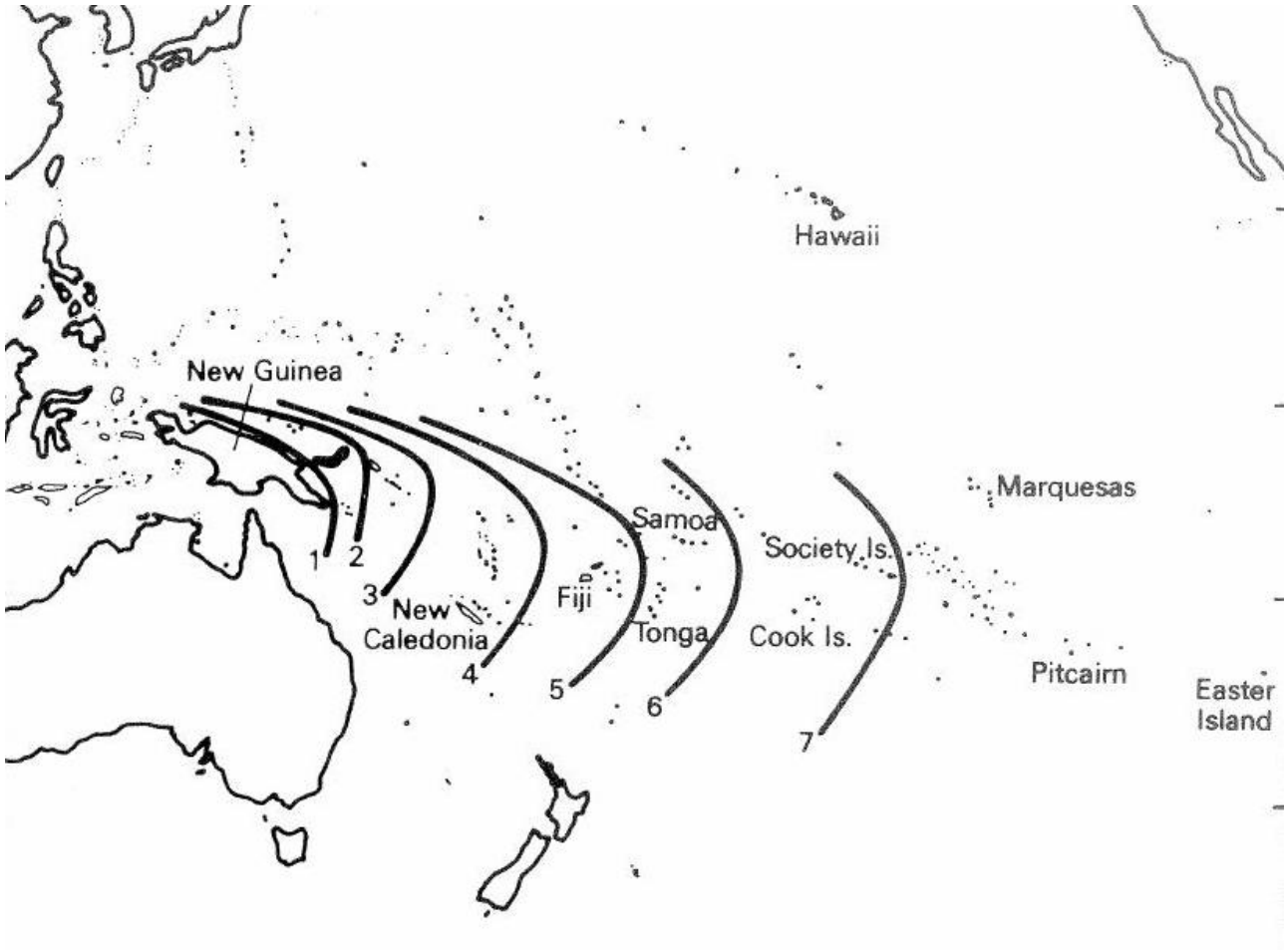
- Species poor
- Disharmony
- High Endemicity

Insular Evolution

- "Untypical" creatures
- Adaptive radiation

Distribution limits of New Guinea bird (sub)families on east pacific islands

1, -14 taxa → **2**, -2 taxa → **3**, -10 taxa → **4**, -7 → **5**, -4 → **6**, -7 → **7**, -3 → . . .



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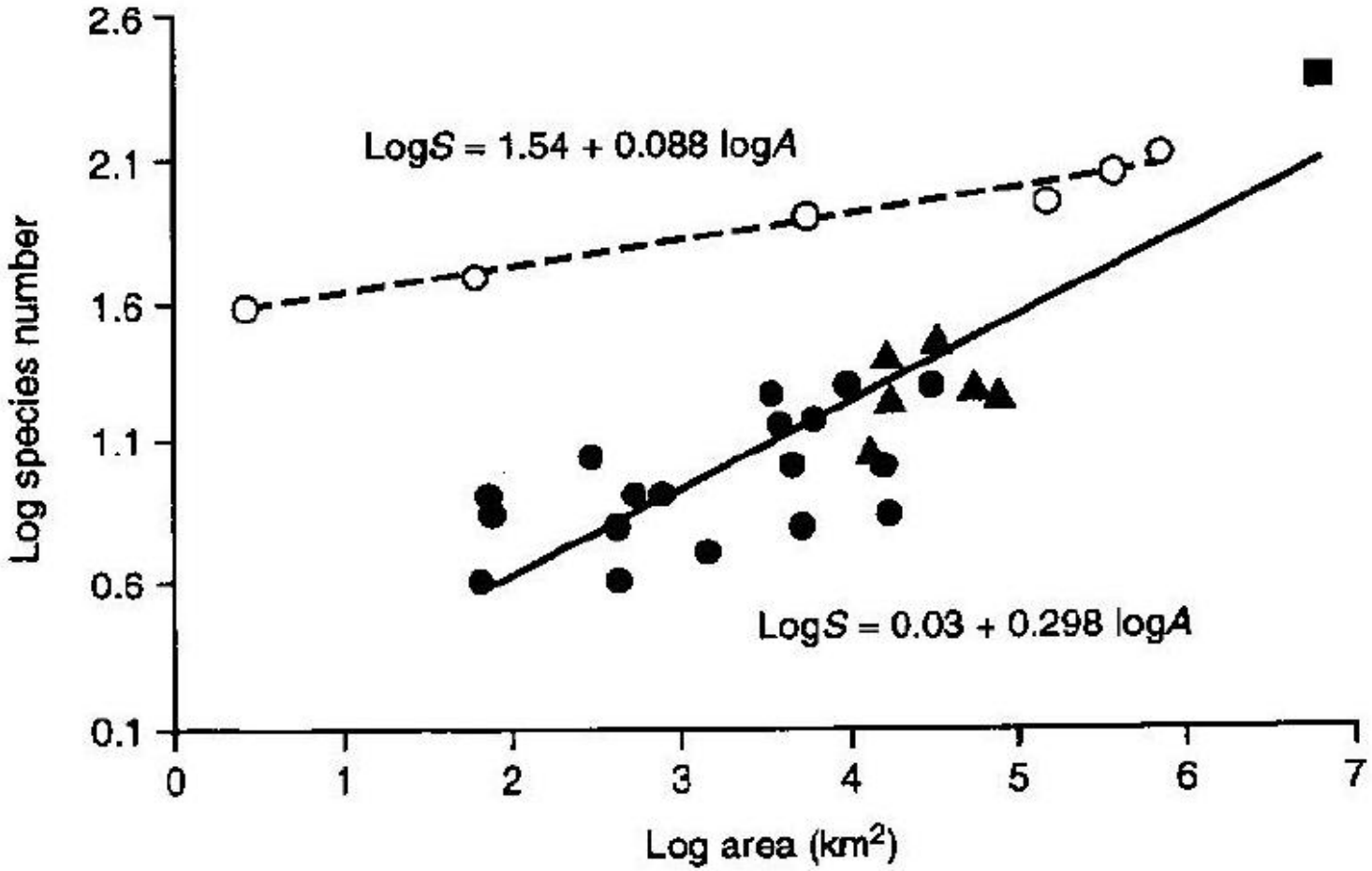
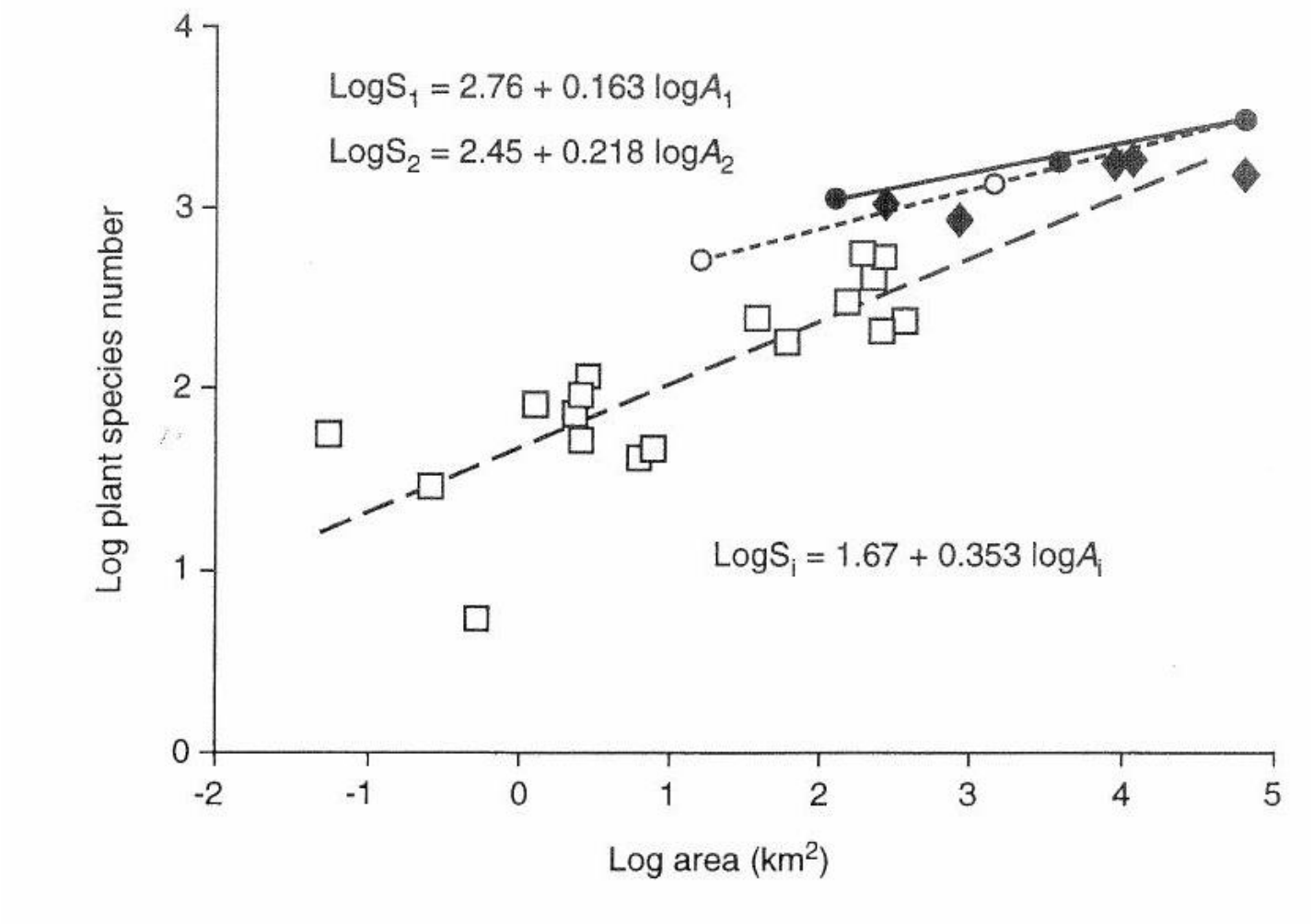
Island area and species richness species-area curves

Ant species in New Guinea and Melanesia.
Mainland-island comaprison.



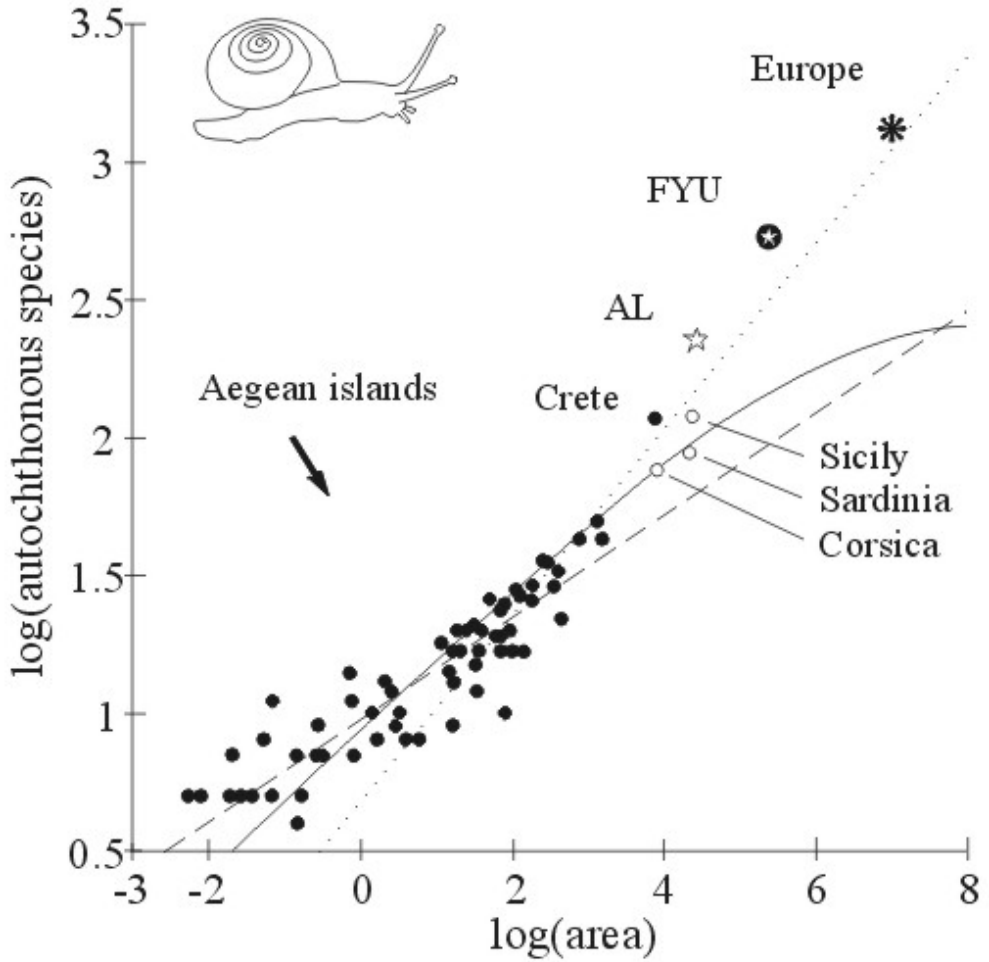
Island area and species richness species-area curves

Plant species in Californian islands.
Mainland-island comaprison.



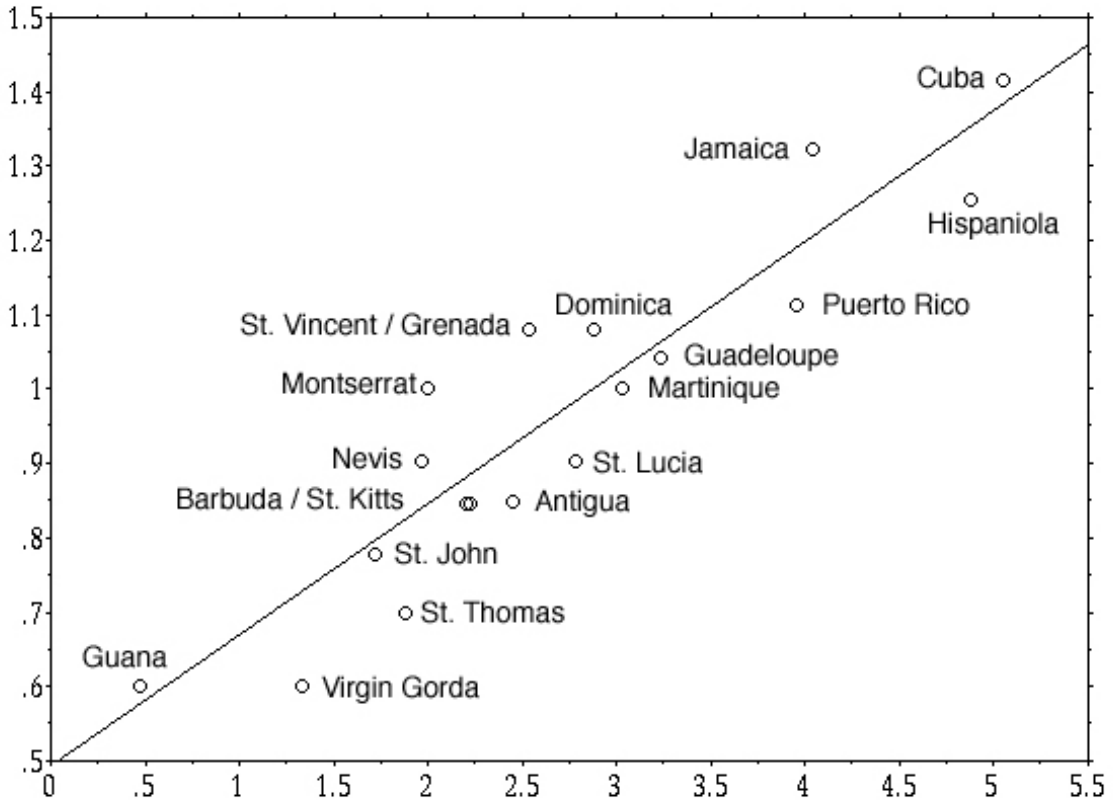
Island area and species richness species-area curves

Landsnail species in Aegean islands.



Island area and species richness species-area curves

Bat species in West Indies.



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Species poverty summary

- Islands are species-poor, compared to similarly-sized areas within continents / mainland.
- Species richness decreases with increasing isolation and decreasing island area.
  → Probabilistic arrival on islands – smaller more distant islands require longer dispersal and present a smaller target for dispersers.
- Young age of oceanic islands also affects probabilistic arrival – contributes to poverty.
- Usually presented as a species-area relationship (SAR) curve.
- Steeper SAR curves for islands and archipelagos than for plots within mainland.

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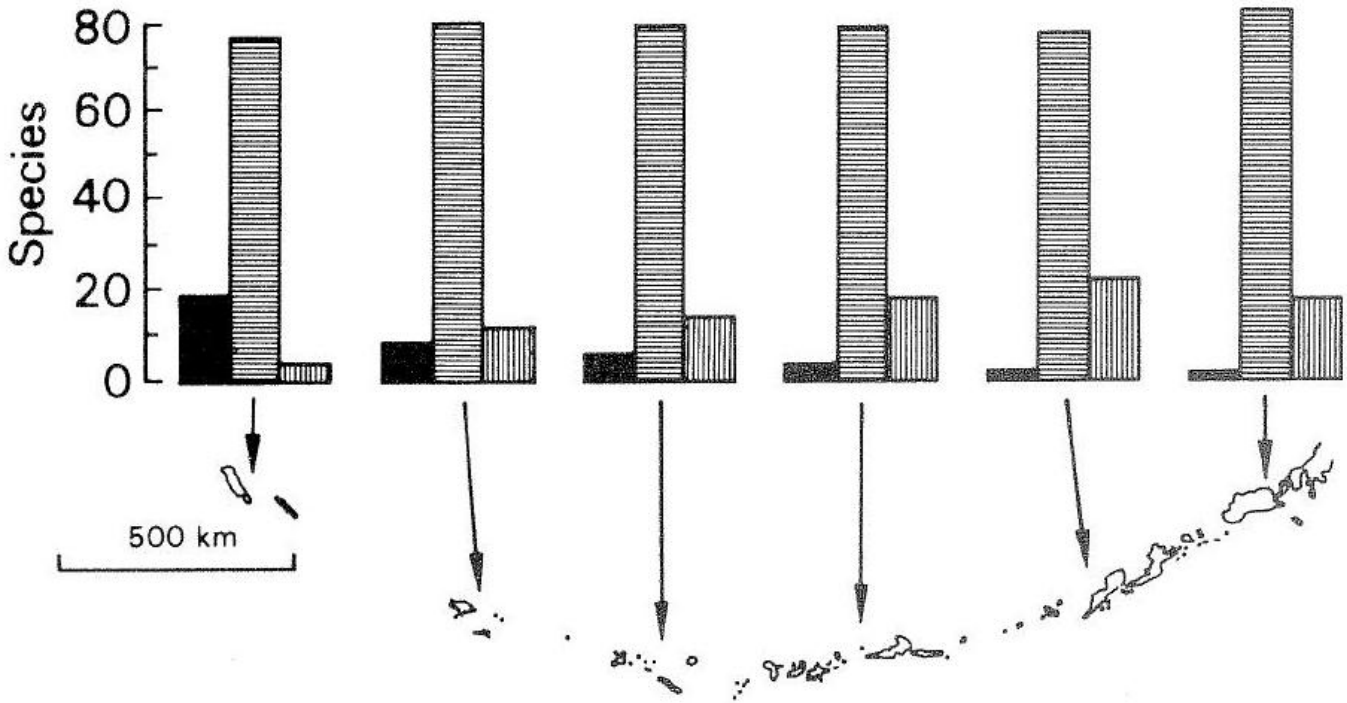
Biogeographic realms

Islands may gain immigrants from different realms!

Disharmony due to mixing of biogeographic realms

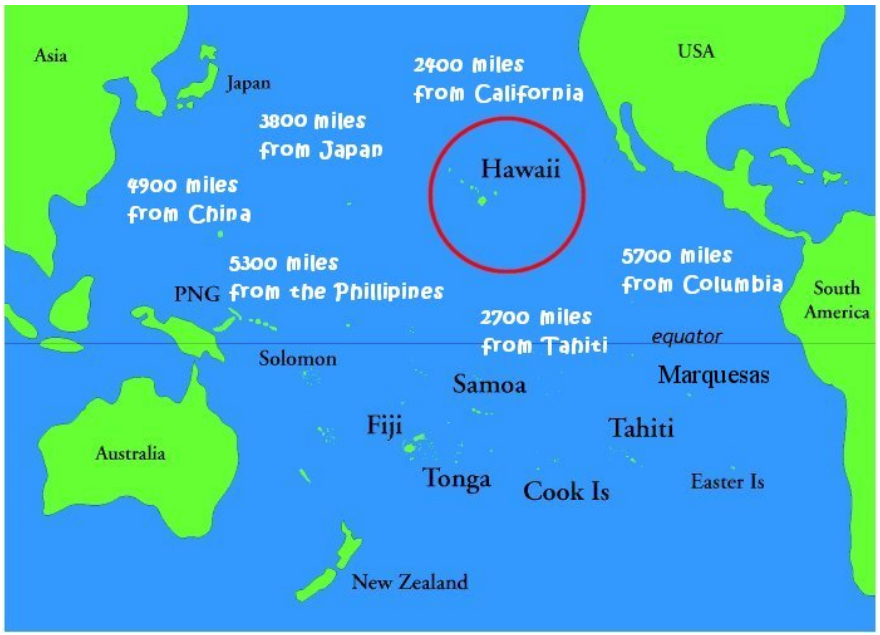
Double filter effect in plant species of the Aleutian archipelago – Palearctic-dominated to the east; Nearctic-dominated to the west.



Disharmony due to mixing of biogeographic realms

Flowering plants of Hawaii (supposed 272 original colonist species):

Origin	Percent
Indo-Pacific	40%
Austral	16-17%
American	18%
North	3%
Cosmopolitan	12-13%



Distribution limits of New Guinea bird (sub)families on east pacific islands

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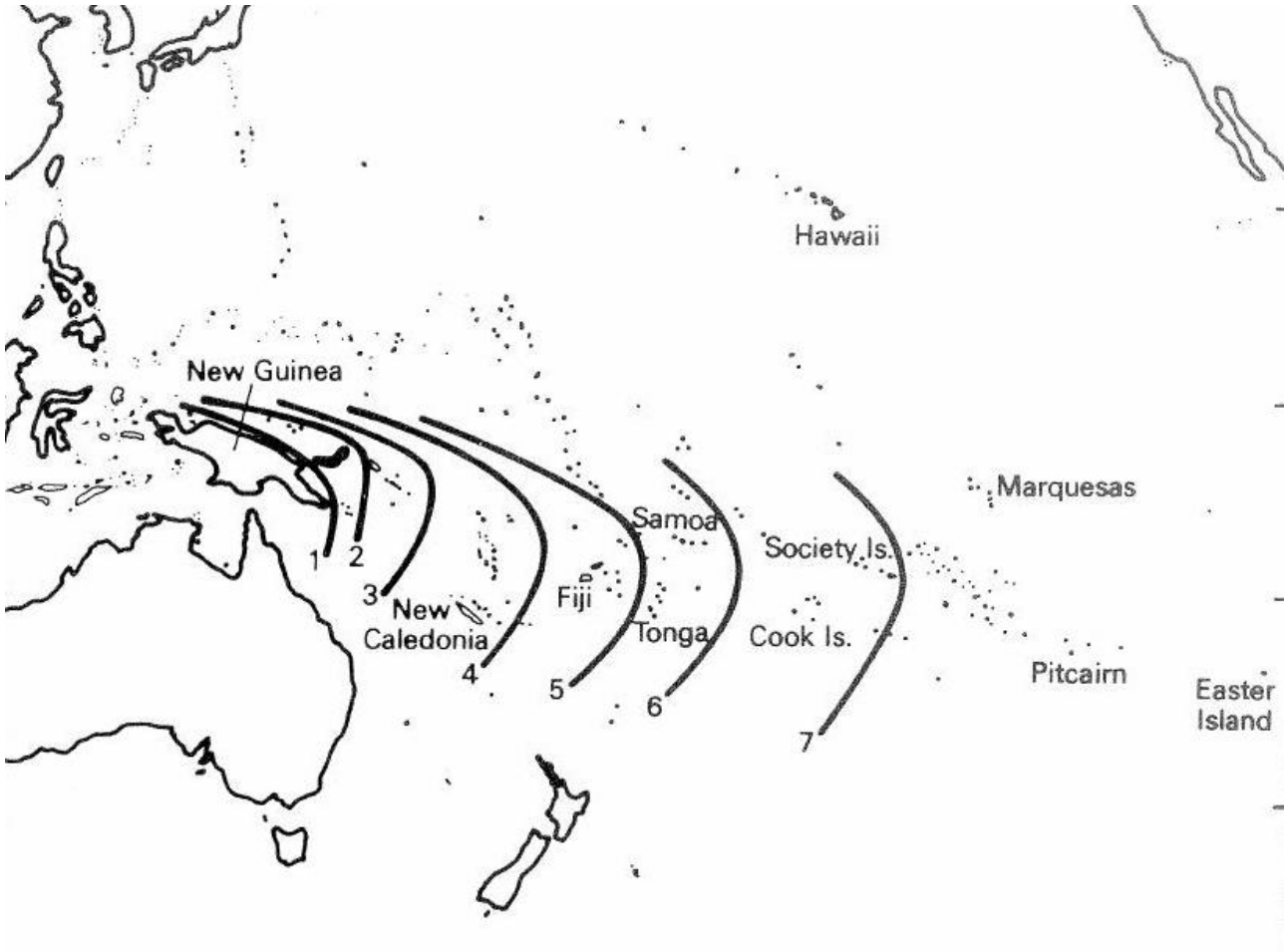

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Disharmony in taxonomic composition

- " . . . islands are disharmonic in that effectively they sample only from the dispersive portion of the mainland pool." (Whittaker 1998, p.35).

- **Examples:**
- 8 families of flowering plants make more than 50% of Hawaiian native species – mostly groups represented by herbaceous plants on continents (e.g., Asteraceae). (Compare with over 400 families worldwide).
- Absence of mammals (except bats) on most islands.
- Tristan da Cuncha and Azores – no land mammals or amphibians – land vertebrates that are not very resistant to desiccation and saltwater.
- Tristan da Cuncha – no birds of prey – predators are also absent on many oceanic islands.
- An establishment problem – usually their prey is also rare or absent.

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- An establishment problem – usually their prey is also rare or absent.
- Bias towards taxa that are highly dispersive, able to reproduce asexually or self (lizards,plants, landsnails), and resistant to long voyages over sea and air.

Species disharmony summary

- Two types of disharmony that operate jointly:
  1. Mixing of different biogeographic realms.
  2. Species composition biased toward specific taxonomic groups.
     - High dispersal ability.
     - May self or reproduce asexually.
     - Resistant to desiccation (and other stresses).
     - Lower trophic level (predators are rarer).
- Disharmony also increases with isolation and as island area decreases.

Outline

Global biodiversity numbers

Islands comprise less than 3% of land area worldwide (much less if you consider only oceanic islands).

They however contribute disproportionately to global biodiversity (species richness):

Group	**Global**	**On islands**	**Percent on islands**
Higher plants	263,000	36,500	13%
Landsnails	35,000	-	8-9%
Birds	-	1750	17%
Anolis lizards	300	-	50%
Flying fox bats	161-174	55	31-34%

- How can we reconcile that with the clear observations of species poverty on islands?

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- How can we reconcile that with the clear observations of species poverty on islands?
  1. There are many islands (much more than continents).
  2. High proportion of **Endemicity** on islands.