Lecture 7

Adaptive Radiation on Islands

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Outline

South pacific episode: Castaways

Episode deals mainly with dispersal and colonization of islands, starting from New Guinea and moving eastward into increasingly isolated islands.

Pay attention to:

1. Numbers and patterns indicating increasing species poverty and disharmony with increasing isolation. Species number decreases, and entire groups of animals or plants become absent.
2. What makes some animals and plants successful colonizers? and why other are poor colonizers?
3. Examples of niche shifts on islands.

Outline

Species concept: a practical definition

- The unit of biodiversity.
- But what is a species?

No one definition has as yet satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species.

Darwin, 1859

. . . I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms.

Darwin, 1859

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.

Conditions promoting differentiation and speciation

- Isolation –
  - Between mainland and islands.
  - Among individual islands in an archipelago.

  Genetic and phenotypic differences may accumulate over time among unconnected populations – resulting in differentiation.

- Different environments – different subpopulations of a species may be exposed to different environments and eventually become differentiated phenotypically and genetically
  (if also some sort of isolating mechanism operates).

- **Speciation** (התמיינות) – the process by which new species are created from an ancestor species.
  In effect, differentiation at the extreme.

Conditions promoting differentiation and speciation

- The **biological species concept** relies on **reproductive isolation** between groups (originally derived from the same ancestor species) – preventing the exchange of genes and promoting differentiation over time.
  - **Prezygotic isolation** – geographic isolation, assortative mating, etc.
  - **Postzygotic isolation** – abnormal embryonic development , offspring inviable or infertile, etc.
- Prezygotic isolation may be behavioral – through mate choice and assortative mating.
- $\Rightarrow$ viable and even fertile hybrids may be produced (e.g., in the lab), but in nature, they do no occur frequently, because mating between groups is rare or nonexistent.

Conditions promoting differentiation and speciation

- Given enough time, **both** postzygotic and prezygotic isolation will be established.
- But significant phenotypic differentiation between groups may happen long before that.
- Speciation may be
  - **Allopatric** – through a prolonged period of geographic isolation between groups, before (and if) they come into contact again.
  - **Sympatric** – no geographic isolation, but some other isolating mechanism operates (e.g., assortative mating based on type of food used).
- The biological species concept is useful and operates pretty well, but like any other theoretical model or concept in science, it has limitations.

Conditions promoting differentiation and speciation

- Even designation into separate species (rather than subspecies, or varieties) is somewhat arbitrary.
- Even within "official" species there is much variation, and groups that demonstrate assortative mating (for example, humans with respect to culture, education, geography, income, etc.).
- The processes of evolution, differentiation and speciation occurs continuously in time.
- $\Rightarrow$ Differentiation between groups (genetic and phenotypic) occurs before they "become" separate species, but also continues after – so the exact point of speciation is somewhat arbitrarily defined.
- The absence of intermediates (due to extinction over long evolutionary time) is also used to separate species and higher taxa (genera, families, 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**.

ממלכה **Kingdom:** **Animalia** Plantae Fungi …

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

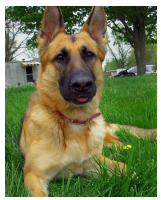
מחלקה **Class:** **Mammalia** Aves Reptilia …

סדרה **Order:** **Carnivora**

משפחה **Family:** **Canidae** Felidae Ursidae …

סוג **Genus:** ***Canis*** *Vulpes* …

מין **Species:** ***Canis lupus*** *Canis mesomelas* …

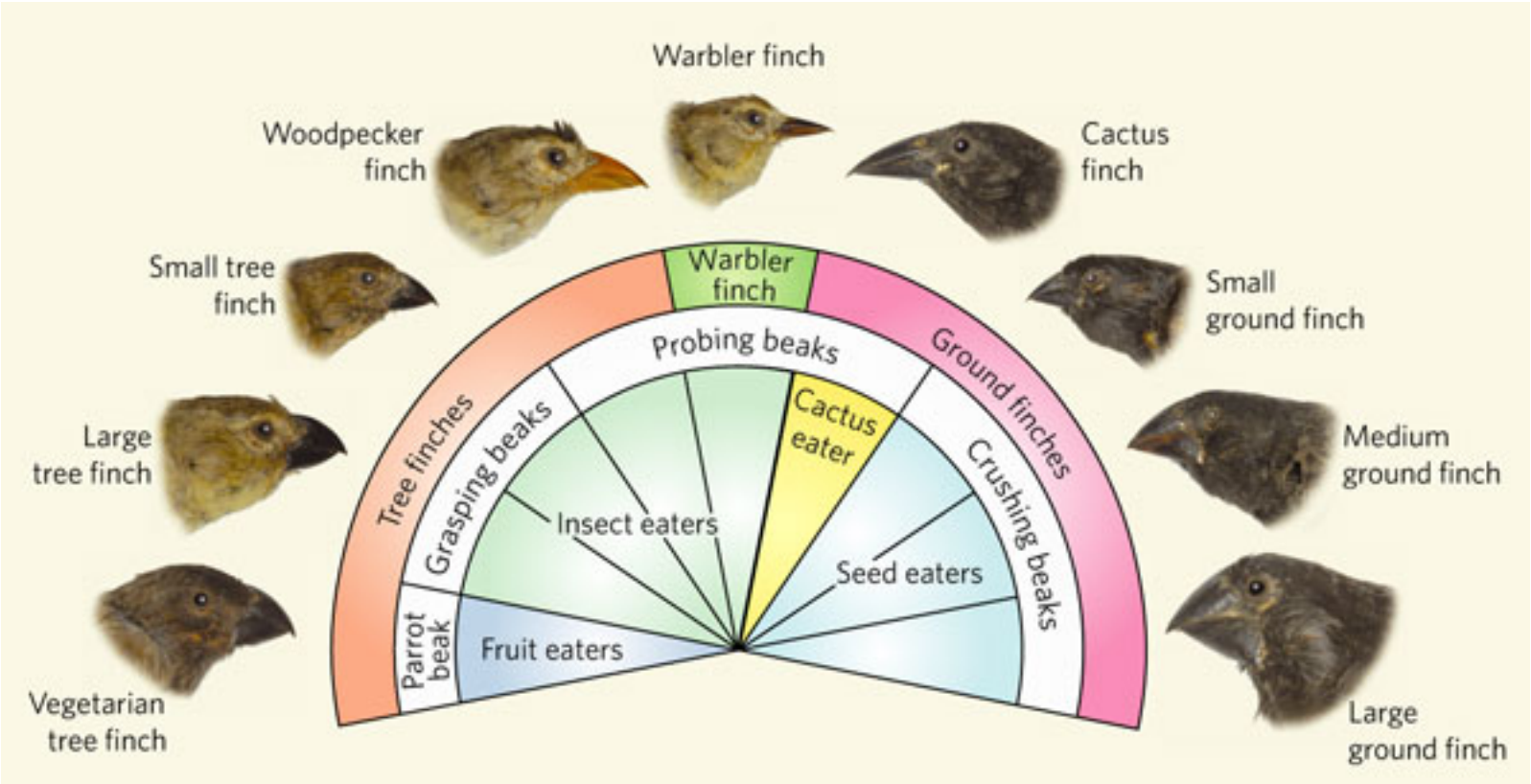


Subspecies, Breed, Variant, Population, Growth form …

Outline

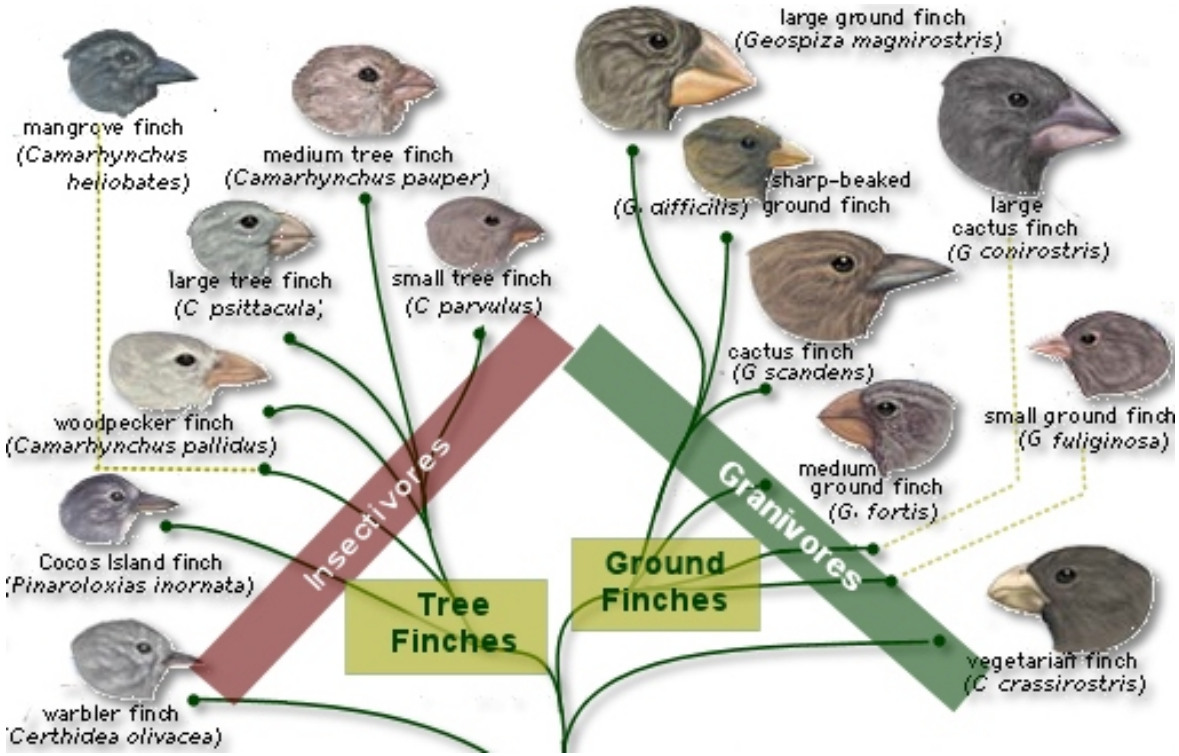
Adaptive radiation: the crowning glory of island evolution

Accompanying the diversification in feeding behavior, was a diversification in beak morphology and overall body size (unlike in the cocos island finch).



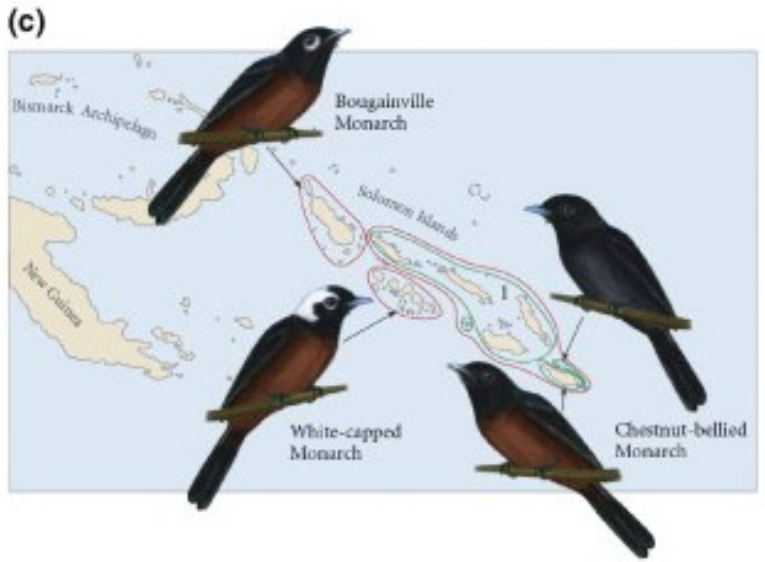
Why "adaptive" in adaptive radiation?

- In adaptive radiation the phenotypic (especially morphological) differentiation and diversification among the groups (species) is associated with niche shifts.
- Involves **adaptation** of the phenotype (morphology) to the new niche.
- For example, in Darwin finches beak morphology evolved and adapted to the changes in feeding niche.



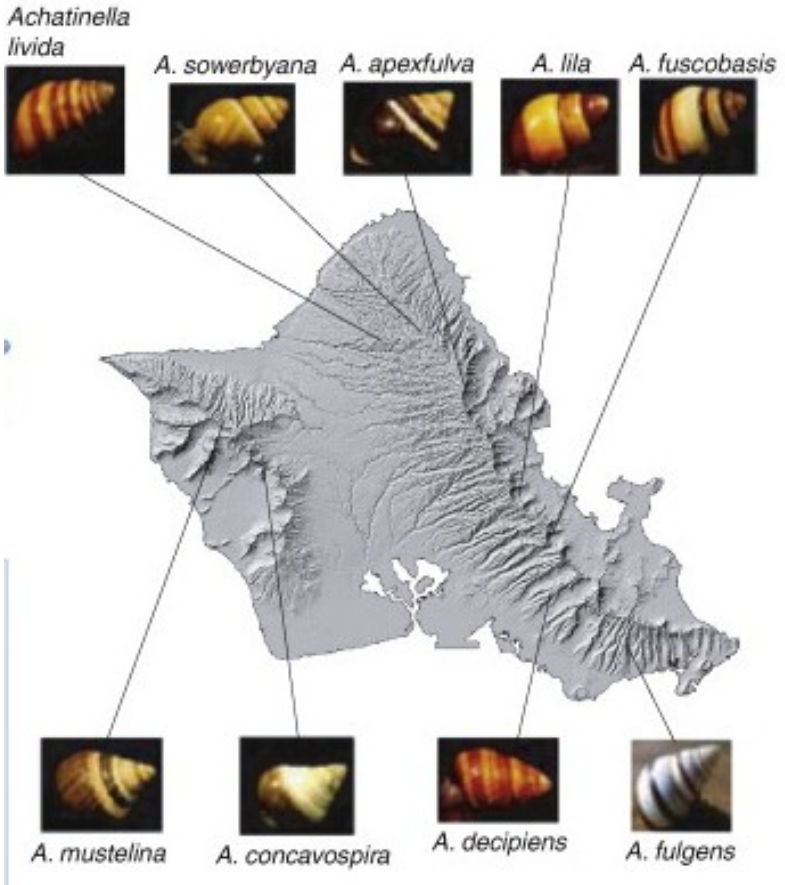
Why "adaptive" in adaptive radiation?

- But morphological differentiation and speciation may occur also without changes in the niches that each group (species) occupies.
- Simply because of isolation and accumulation of genetic and phenotypic differences.
- $\Rightarrow$ **Non**adaptive radiation.
- Example: Flycatchers in Solomon islands.



Why "adaptive" in adaptive radiation?

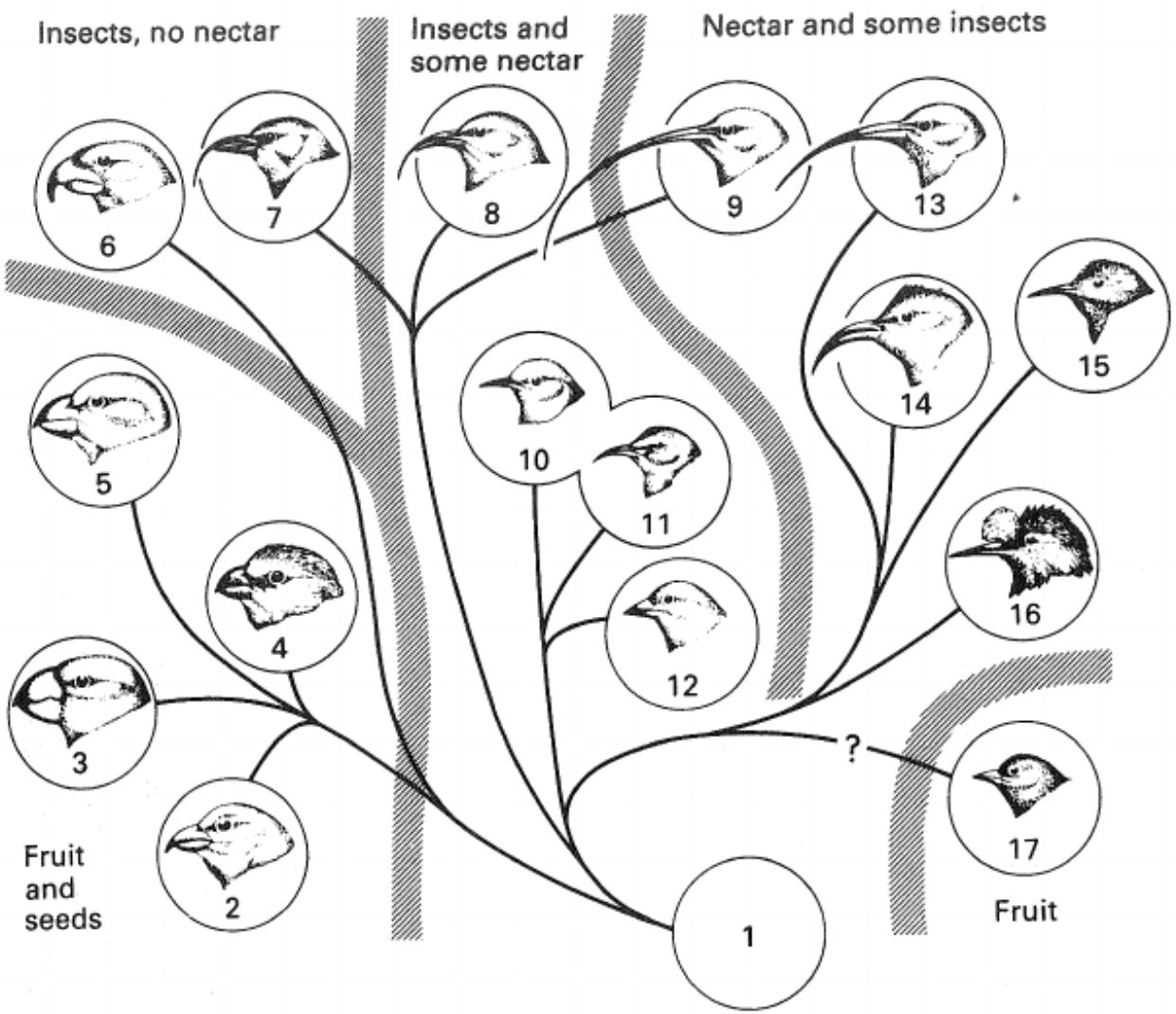
Another example of **nonadaptive** radiation: *Achatinella* – Hawaiian tree snails.



Adaptive Radiation: Hawaiian honeycreepers

Adaptive Radiation: Hawaiian honeycreepers

Diversification associated with a wide array of feeding niches.



Adaptive Radiation: Hawaiian honeycreepers

- Even greater radiation than on Galapagos – one immigrant seed eating species of finch from Asia evolved into over 30 species.
- In the absence of hummingbirds and sunbirds, and in the presence of flowers year round (Ohia lehua and other plants) many nectarivorous species evolved.
- In the absence of woodpeckers and similar bird species, a honeycreeper that bores into wood in search of insect larvae also evolved.
- Additional species specialize in feeding on seeds, insects or fruits.
- Even more spectacular morphological diversification than on Galapagos.

Adaptive Radiation: *Echium* on Canary Islands

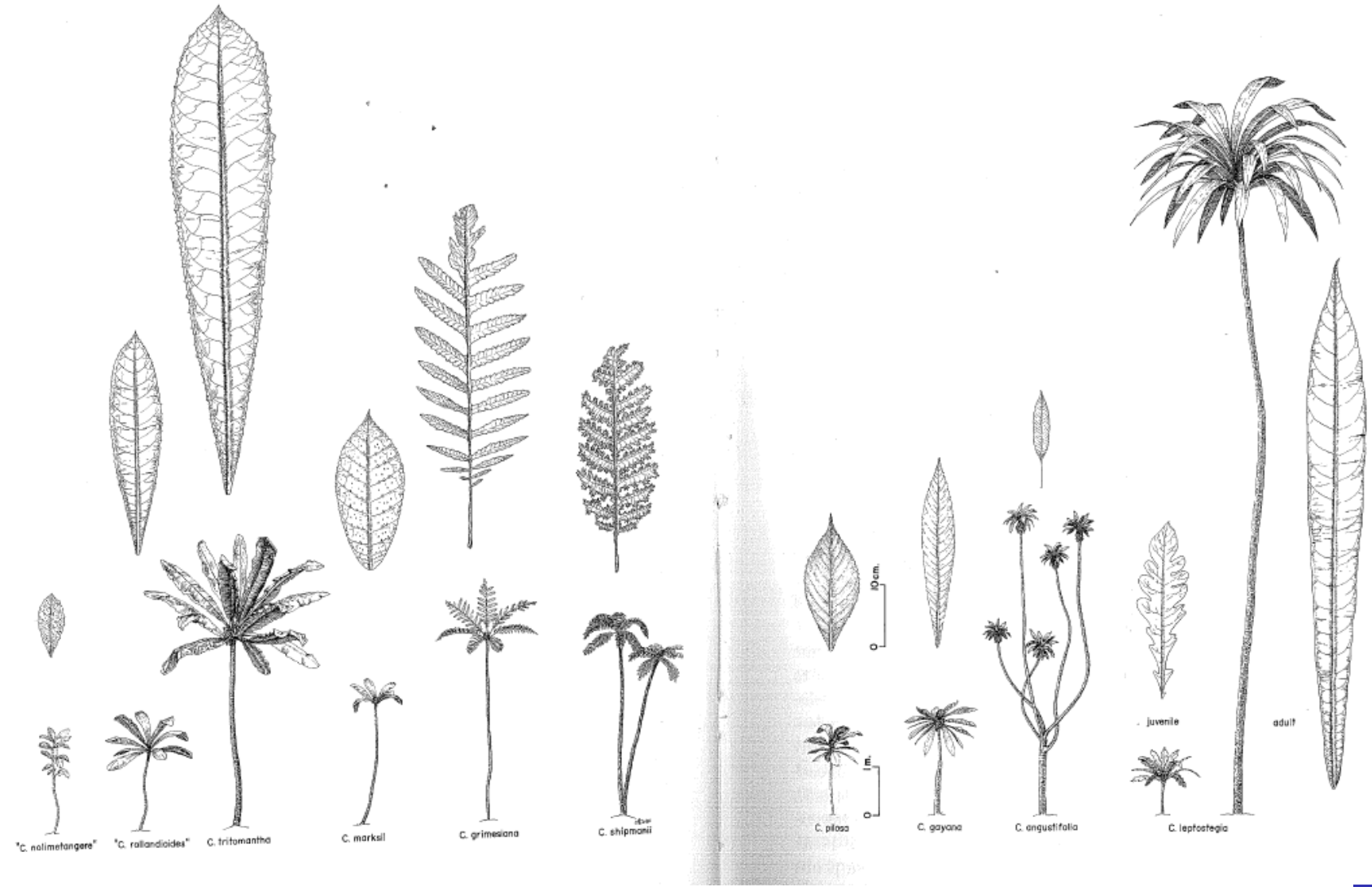
Sonchus on Canary Islands and Madeira

Europe:

Canary islands and Madeira:

Cyanea on Hawaii

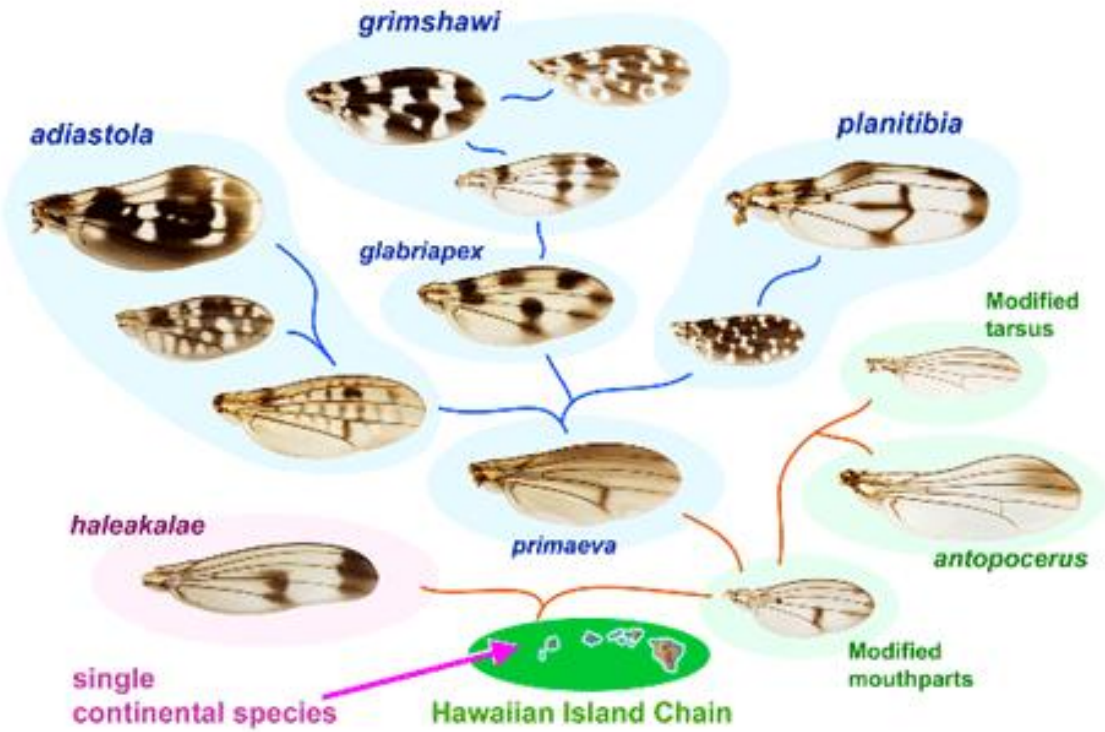
Cyanea is one genus of Hawaiian Lobelioids – Lobelioids radiated tremendously on Hawaii – 125 species in 6 genera (!).



Adaptive radiation in plants

- Diversification of growth form (herb, shrub, rosette tree, branched tree, etc.), in life history (annual vs. perennial), in leaf morphology, etc.
- Differentiation of growth forms and species according to different habitats.
- For example:
  - Forest vs. open habitats.
  - Coastal and lowland vs. upland, montane/sub-alpine, and cliffs habitats.
  - Dry or arid habitats vs. moist and wet.
- Radiation is often in families that are represented on mainland by weedy, annual, highly dispersive forms. For example, Asteraceae.

Hawaiian Droshophilids

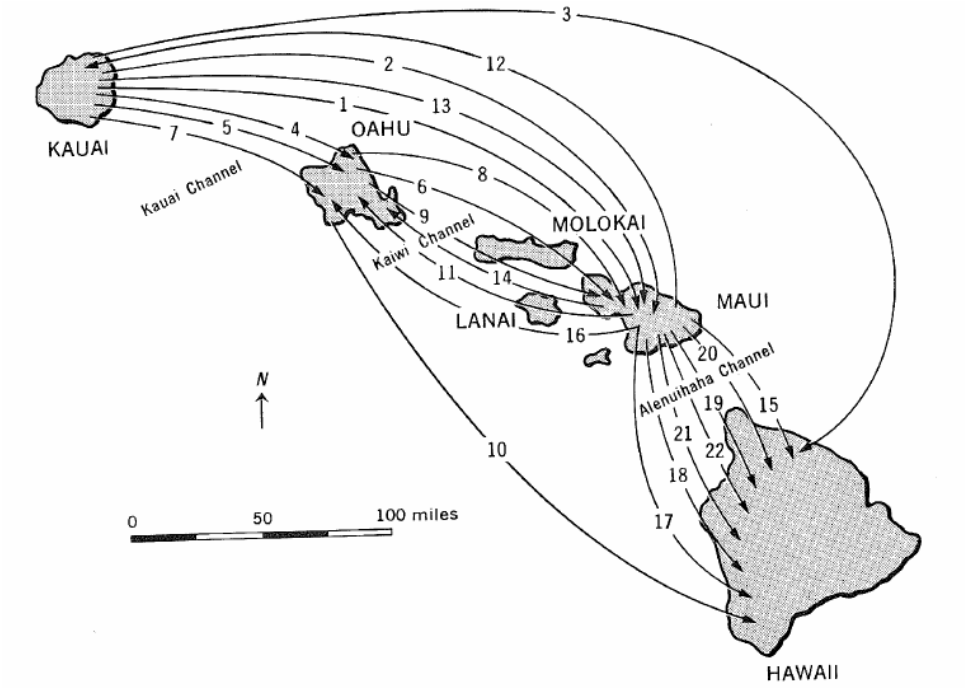


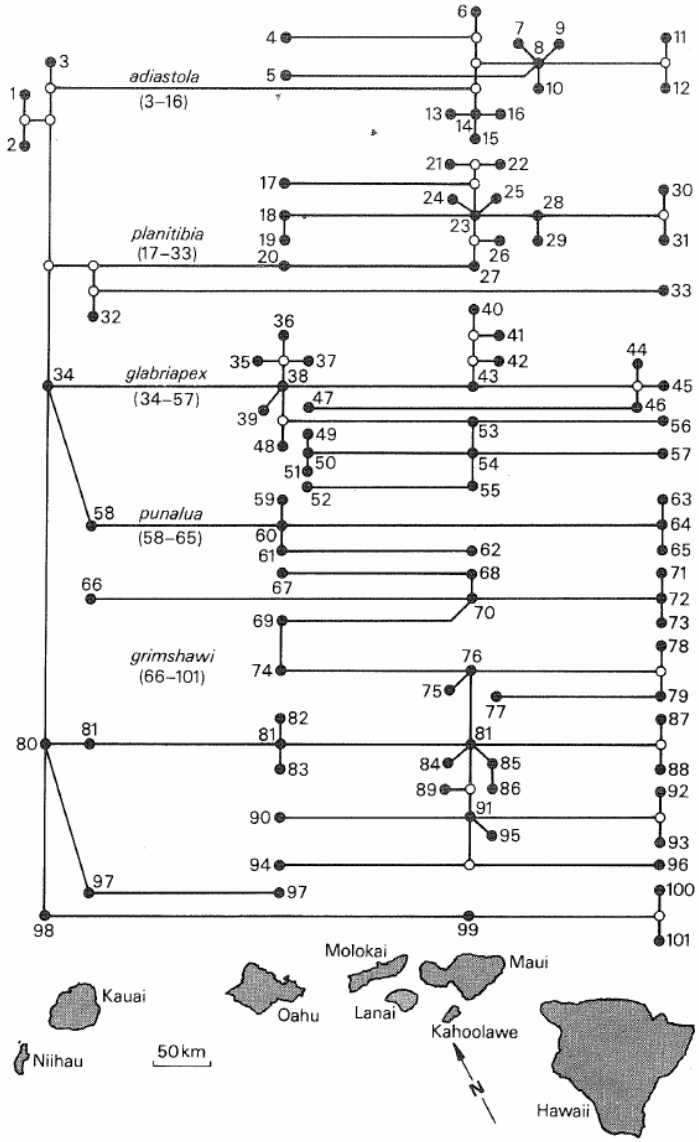
Hawaiian Droshophilids

- Probably, as high as 1000 species.
- Highly diversified in morphology, anatomy, mating behavior, feeding behavior, and habitats they occupy: rotting leaves, rotting bark, in mushrooms, in flowers, in slime fluxes, etc.
- Different from Drosophilids on continents, especially with regard to diet, habitats occupied, morphology and mating behavior.
- Most species occur only on a single island within the archipelago.
- Much of the speciation also occurred because of isolation between different populations on the same island – for example, in valleys separated by steep ridges, and forests divided by fresh lava flows.

Hawaiian Droshophilids

The geographic pattern of Drosophilids radiation on Hawaii:





Evolution on archipelagos and adaptive radiation

- Species poverty and disharmony ⇒ empty niches.
- Isolation from mainland, among islands within the archipelago, and also within parts of a single island.
- Availability of empty niches and isolation together promote differentiation and speciation leading to adaptive radiation.
- Occasional inter-island dispersal further promotes differentiation and speciation.
- For example, may bring together two subspecies that evolved allopatrically on different islands and differentiated in their niche (e.g., feed on different resources)
  ⇒ Competition leads to stronger niche specialization (the opposite of ecological release) and to further prezygotic isolation and differentiation among the now sympatric groups ⇒ Ultimately, leading to speciation.

Other examples of adaptive radiation

- Hawaiian tree crickets and spiders.
- Many plant groups on every oceanic archipelago.
- Wetas in New Zealand.
- *Anolis* lizards in the Caribbean (Greater and Lesser Antilles).