Biogeography of Islands

‘Insular Syndrome’

24 principles

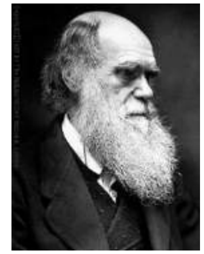
1. difficulties of LDD to islands
2. isolation after establishment
3. ecological opportunities
4. moderation of maritime climate

Adaptive radiations

Dispersal

Dispersal Biology

Charles Darwin (1809–1882)



• LDD key to Darwin’s view of disjunct biogeographical distributions

“. . . they spread as far as barriers, the means of transportal, and the preoccupation of the land by other species, would permit”

“It certainly is the general rule that the area inhabited by a single species or by a group of species is continuous and the exceptions, which are not rare . . . be accounted for by former migrations under different circumstances, or through occasional means of transport, or by the species having become extinct in the intermediate tracts”

(Darwin, 1859)

Dispersal Biology

• Darwin’s experiments on long distance dispersal (LDD) at Down House

• 87 plant species examined

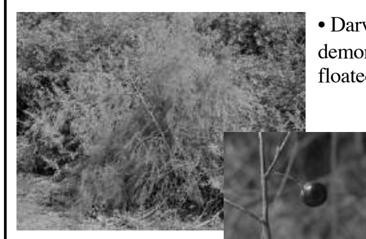
Problem: all sunk to bottom of vials!

• 64 germinated after an immersion of 28 days in salt water tanks

• few germinated even after 137 days of immersion

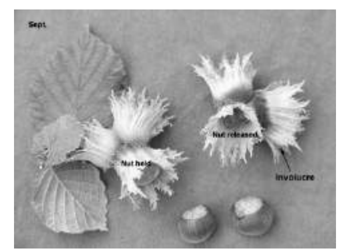
• the laboratory: cellar at Down House

Dispersal Biology



• Darwin extended these experiments by demonstrating dehydrated seeds and stems floated better

• asparagus floated for 32 days and then germinated



• Darwin concluded, based on Atlantic current speeds (33 miles/day), that seeds floating 28 days would travel 924 miles at sea

• hazelnut stems with fruits floated for 90 days and then germinated

Dispersal Biology


• Darwin also studied other, more irregular, means of transport

• attached to feet or feathers of birds, or inside the gizzard or digestive tract

Hawaiian *nene*

Dispersal Biology

• Darwin also studied other, more irregular, means of transport

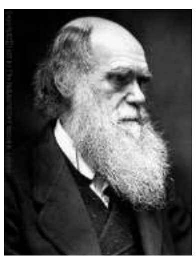
• suspended duck feet in aquarium stocked with freshwater snails



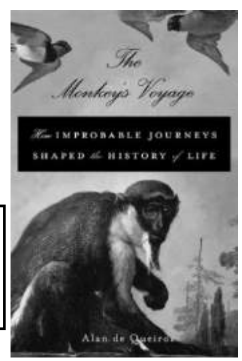
• molluscs crawled on, clung tightly in air for 12-20 hours — Darwin argued that duck or heron would have flown 700 miles

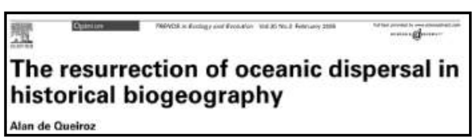
Dispersal Biology

• Fast forward to 2019 - Darwin was both right and wrong



• Trans-oceanic dispersal now clearly supported
• Continents, clades, and clock evidence



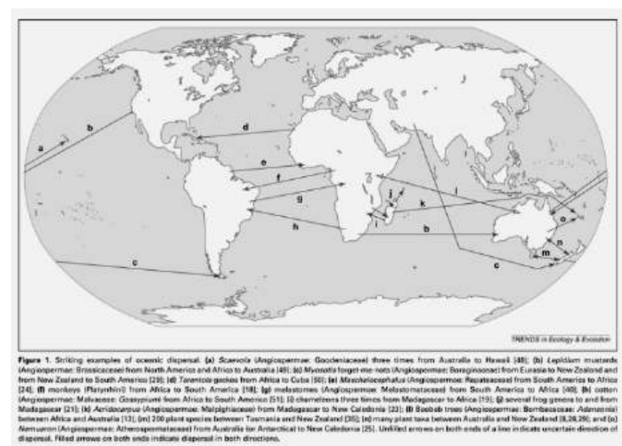


The resurrection of oceanic dispersal in historical biogeography

Alan de Queiroz

Dispersal Biology

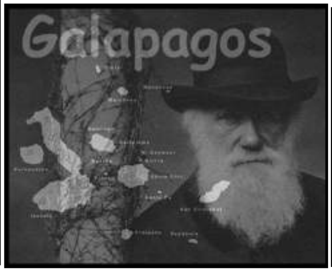
• deQueiroz (2005) *Trends in Ecology and Evolution*

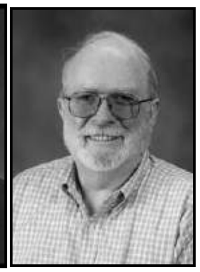


Galapagos Flora

- volcanic islands, 800 km from continental source area
- 522 (550 in 2019) indigenous (native) vascular species
- 181 (880 in 2019) introduced ‘weeds’ - a feature of island biogeography

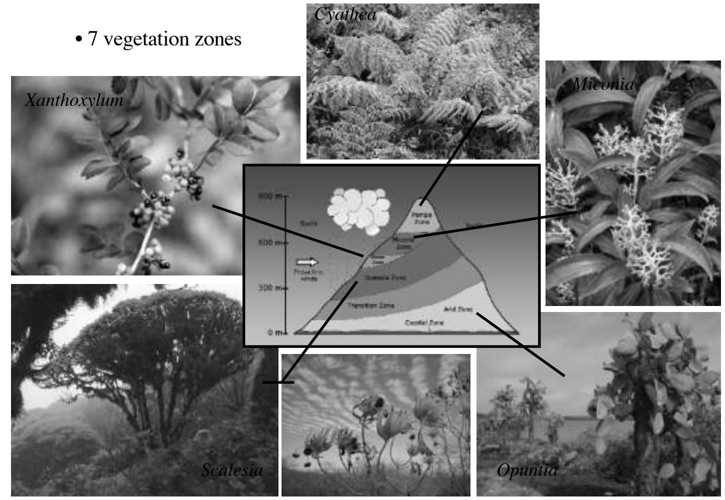
Duncan Porter 1976 “*Geography and dispersal of Galapagos Islands vascular plants*” Nature 264:745-746





Galapagos Flora

- 7 vegetation zones



Galapagos Flora

Indigenous flora - make up of an island biota

- 522 native species – depauperate!
- 45% of species are endemic to the islands
- ferns and relatives have low endemism
- 98+% of non-endemic species also occur in South America – source!

Table 1 Geographical relationships of the indigenous vascular plants of the Galapagos Islands

	Endemic	Neotropical	Pantropical	Andean	Mexico and Central America	South America	Total
Pteriodophytes	8	52	14	15		2	91
Monocotyledons	20	38	22	3			83
Dicotyledons	208	65	26	43	4	2	348
Total	236 (45%)	155 (30%)	62 (12%)	61 (12%)	4 (1%)	4 (1%)	522

Galapagos Flora

How did the plants get there?

- 181 non-native species by 1976 in addition to 522 native species
- humans are a big disperser!

- Hooker (1847) commented on aliens
- 475 by 1999
- 600+ species today

Table 2 Original introductions that have resulted in the present vascular plant flora of the Galapagos Islands

Introduced	Birds	Man	Wind	Oceanic drift	Total
Pteridophytes	1		86		87
Monocotyledons	58	38	14	2	112
Dicotyledons	166	143	18	33	360
Total	225 (40%)	181 (32%)	118 (21%)	35 (6%)	559
Total for natural introductions	225 (60%)		118 (31%)	35 (9%)	378

Galapagos Flora

Humans, islands, and exotics

- invasives (quinine, guava, grasses, dutchman's pipe)
- humans, exotics, and islands go hand in hand

Cinchona (quinine) on Santa Cruz

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Galapagos Flora

Julie Denslow
USDA Forest Service, Institute for Pacific Islands Forestry

WEEDS IN PARADISE: THOUGHTS ON THE INVASIBILITY OF TROPICAL ISLANDS[1]

Julie S. Denslow[2]

Abstract

"Weeds in Paradise"

another principle of Island Biology

Galapagos Flora

How did the original colonists get there?

- 378 original colonists (gave rise to 522 native species)
- 60% of original colonists via bird LDD
- 31% and 9% via wind and sea drift, respectively

endemic *Lecocarpus* – 3 species

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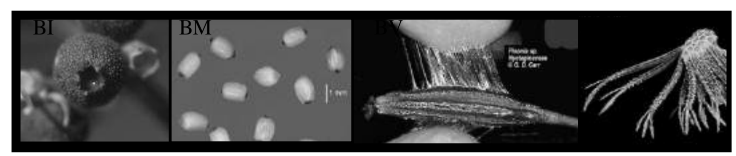
Galapagos Flora

How did the original colonists get there?

- different bird dispersal mechanisms for 225 bird-dispersed colonists

64%	BI	internal digestive system
15%	BM	mud attached to birds
12%	BV	attached by viscid structures of seeds/fruits
8%	BB	attached mechanically by barbs/hooks



LDD to Island Systems

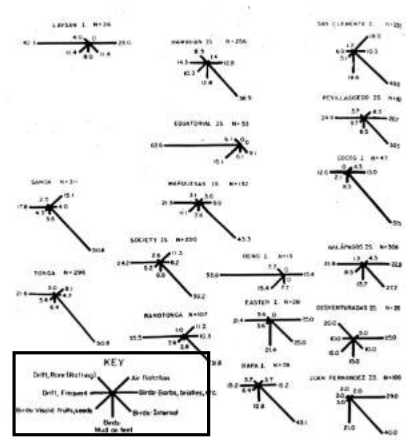
Types of long distance dispersal

A	air or wind flotation
BI	internal digestive system
BM	mud attached to birds
BV	attached by viscid structures of seeds/fruits
BB	attached mechanically by barbs/hooks
DF	oceanic drift - frequent
DF	oceanic drift - rare or rafting

LDD to Island Systems

Patterns of long distance dispersal

- distance and ecology of islands very important in determining which LDD method operates
- see Principle #8 from *Principles of Dispersal and Evolution on Islands* (Carlquist, 1974)



LDD to Island Systems

Patterns of long distance dispersal

- atoll islands are only mid-ocean beaches - drift plants predominate

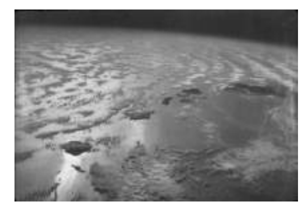
Comparisons of Pacific islands with respect to dispersal types

Dispersal type	Hawaiian Islands	Samoa	Lowest Percentage	Highest Percentage
A	1.4	15.1	0 (Eq. atolls)	18.0 (San Clemente I.)
BB	12.8	4.0	0 (Eq. atolls)	29.0 (J. Fernandez Is.)
BI	38.9	50.8	0 (Oeno I.)	50.8 (Samoa, Tonga)
BM	12.8	5.5	2.8 (Rarotonga)	21.0 (J. Fernandez Is.)
BV	10.3	4.3	2.1 (Cocos Is.)	15.4 (Oeno I.)
DF	14.3	17.8	3.0 (J. Fernandez Is.)	63.6 (Eq. atolls)
DR	8.5	3.5	0 (Cocos Is.)	8.5 (Hawaii)

LDD to Island Systems

Patterns of long distance dispersal

- remote islands low in air flotation since it operates poorly across long distances - such as Hawaii



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LDD to Island Systems

Patterns of long distance dispersal

• wind dispersal effective for short distances *for most plants*

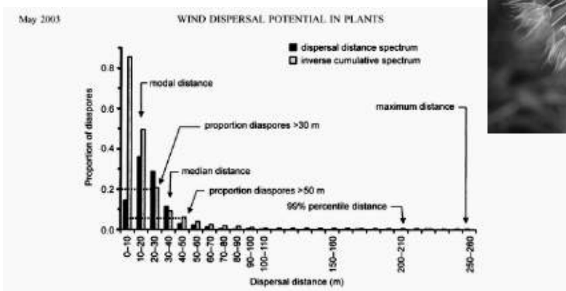

FIG. 1. Hypothetical dispersal distance spectrum showing frequency distributions of dispersal distances, and some possible measures of the dispersal potential. The inverse cumulative spectrum shows the proportion of diaspores exceeding the respective distance.

Ecological Monographs 73:191-205

LDD to Island Systems

Patterns of long distance dispersal

• but air flotation is high on near islands such as San Clemente off of western North America

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LDD to Island Systems

Patterns of long distance dispersal

• bristly fruits correlated with dry forested islands such as Juan Fernandez Islands, or where birds are very active

Comparisons of Pacific islands with respect to dispersal types

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LDD to Island Systems

Patterns of long distance dispersal

• fleshy fruits correlated with wet forested, montane islands (Samoa, Tonga) - effective LDD method as found in remote islands (Hawaii)

Comparisons of Pacific islands with respect to dispersal types

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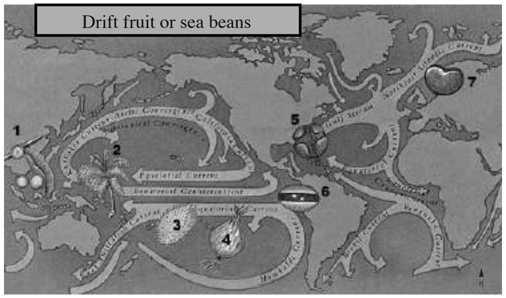
LDD to Island Systems

Final thoughts - 1. dispersal does not = establishment!



1. Tamanu (*Calophyllum inophyllum*), Indonesia to the Philippines.
2. Coconut (*Cocos nucifera*), Melanesia to Eastern Australia.
3. Nickernut (*Caesalpinia bonduc*), Tropical America to Canton Island.
4. Box Fruit (*Barringtonia asiatica*), Islands of Micronesia to Tahiti.
5. Mary's Bean (*Merremia discoidesperma*), Central America to Florida.
6. Sea Bean (*Mucuna sloanei*), Tropical America to Galapagos Islands.
7. Sea Heart (*Entada gigas*), Tropical America to Mexico and Europe.

LDD to Island Systems

Final thoughts - 1. dispersal does not = establishment!

- *Mucuna* - American tropical legumes regularly disperse to Hawaiian beaches, *but seldom have established*

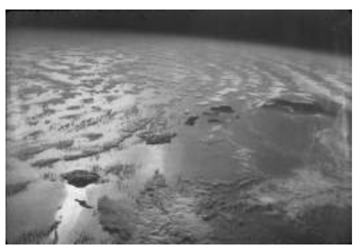
- Principle # 5 - elements present in proportion to both ability to disperse and establish (ecology of island)

LDD to Island Systems

Final thoughts - 2. “disharmony” in flora is evidence for LDD

- Hawaiian flora composition (families and genera) is strikingly different than that found on mainlands

- Filter allows selective families, genera, species for LDD - island flora not in harmony with source area flora or disharmonic



- Principle # 1 – disharmony in island flora composition is evidence of LDD