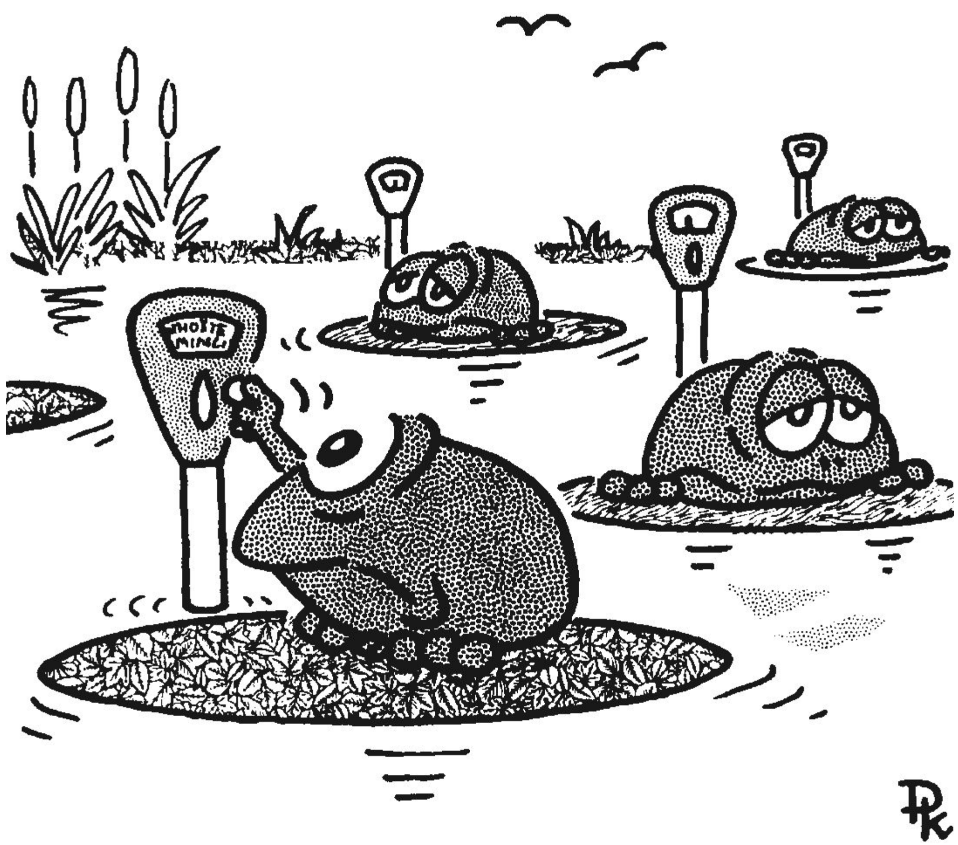
Island biogeography: diversity on regional scale



Content

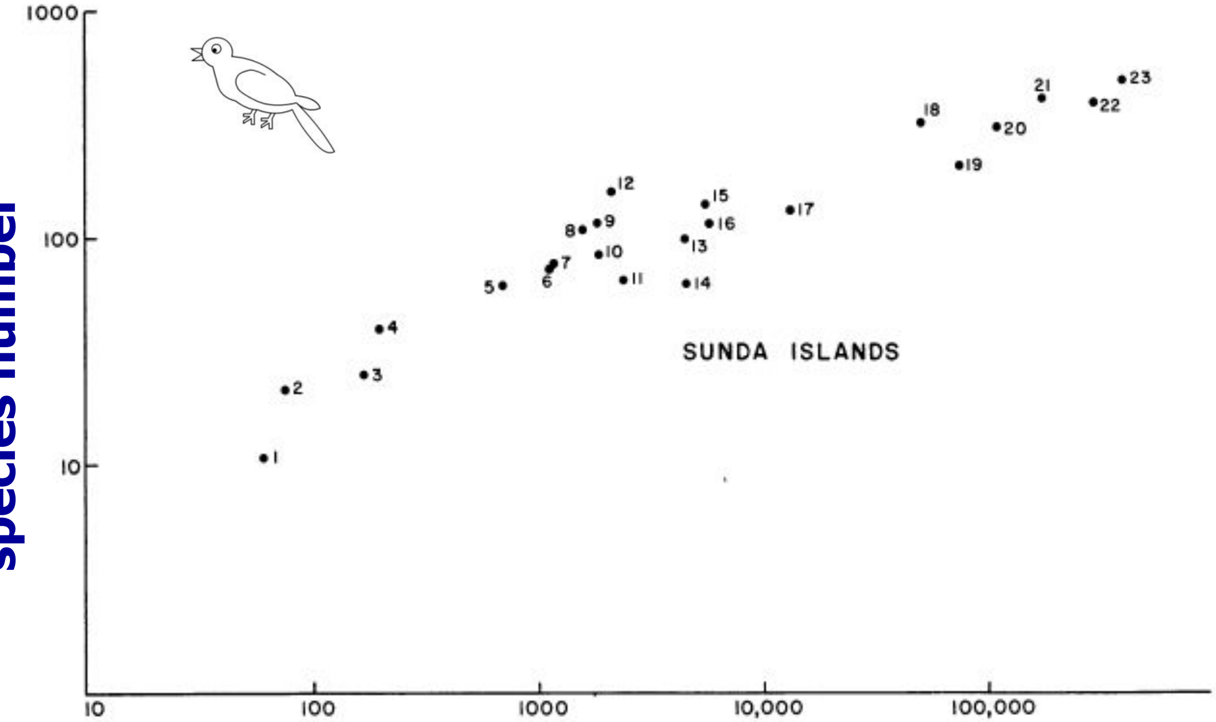
- **equilibrium** model
- effect **area heterogeneity**
- **species evolution** in islands

Diversity on regional scale

- scale min. of hundreds km -> peninsulas, continents
- no effect of local **abiotic factors**, **competition** and **predation** (local div.)
- effect of **climate**, **ranges of particular species**, **geographic barriers**, **speciation** processes

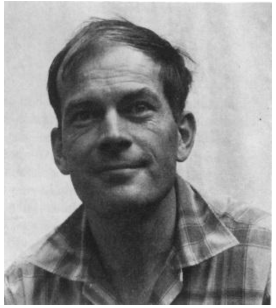
Number of species increase with island area

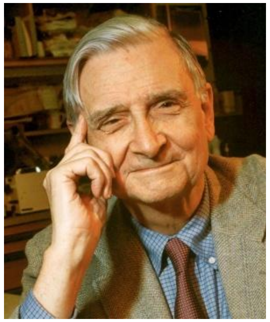
MacArthur & Wilson (1963)



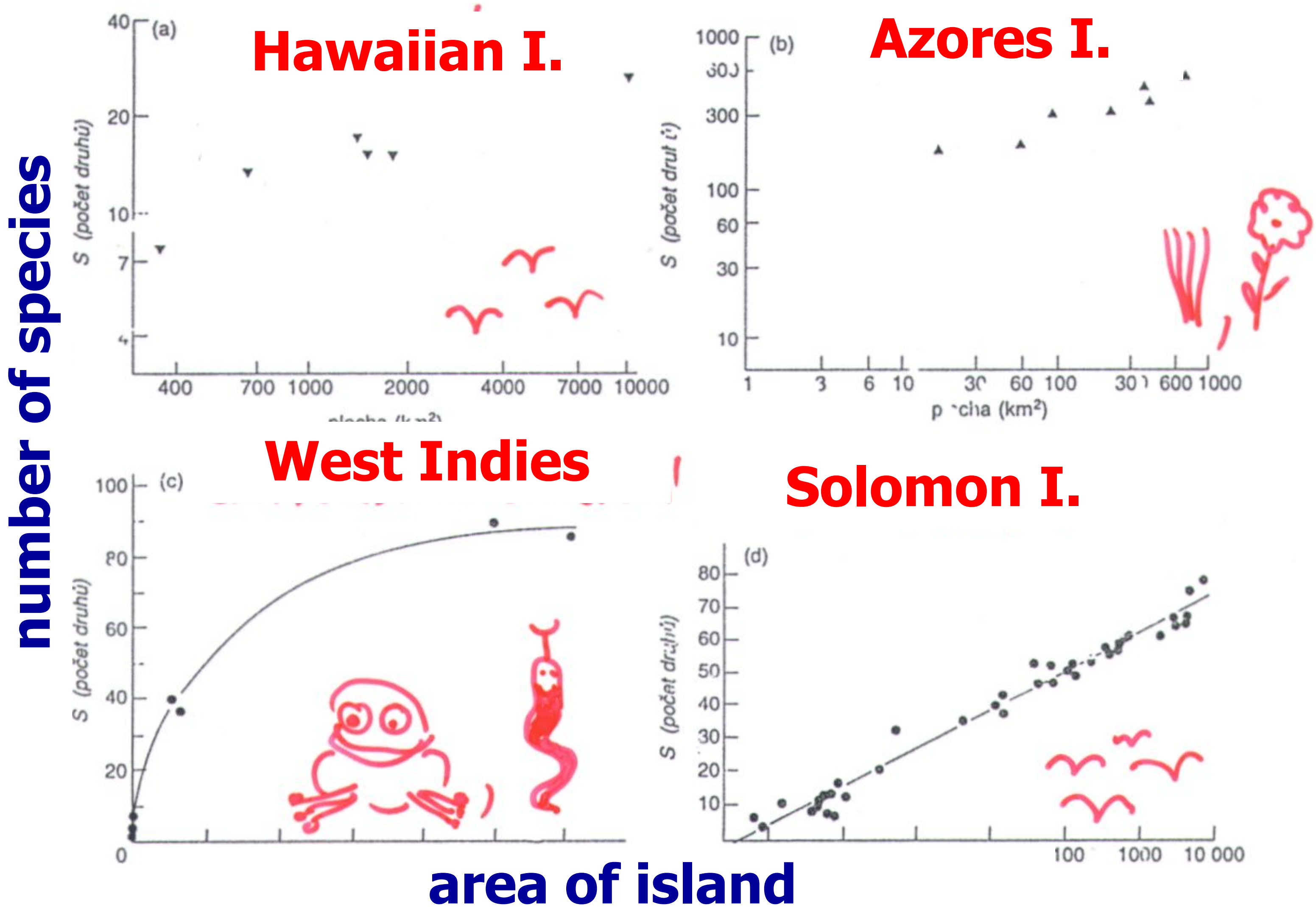
species number

island area



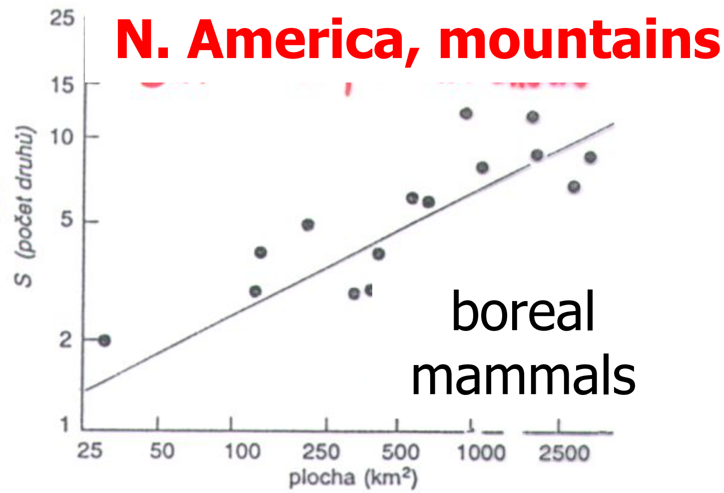


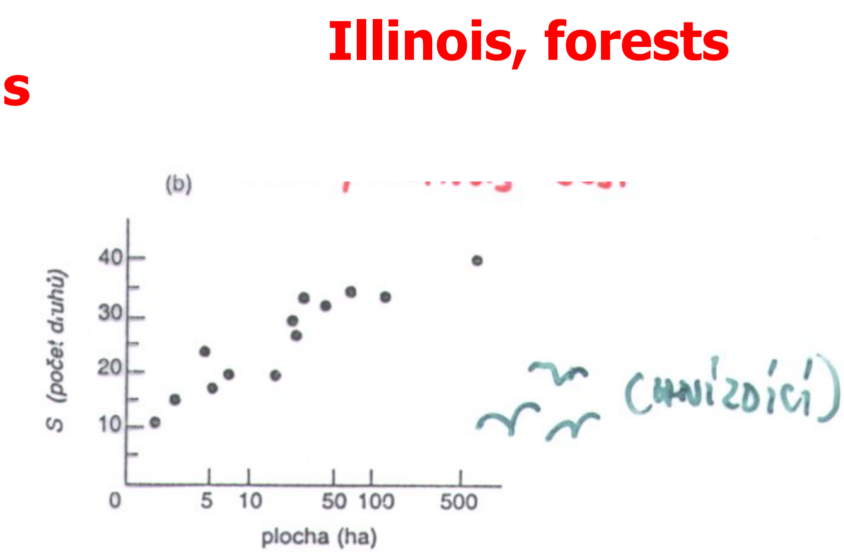
Number of species increase with island area

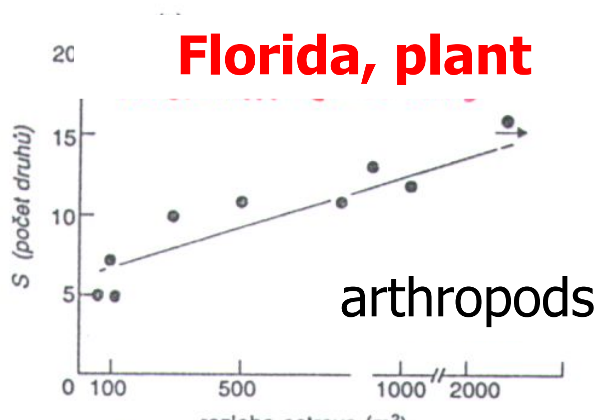


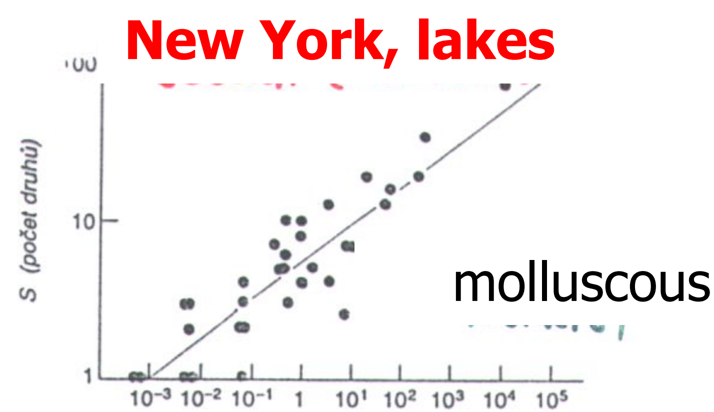
The same pattern for habitat islands

number of species



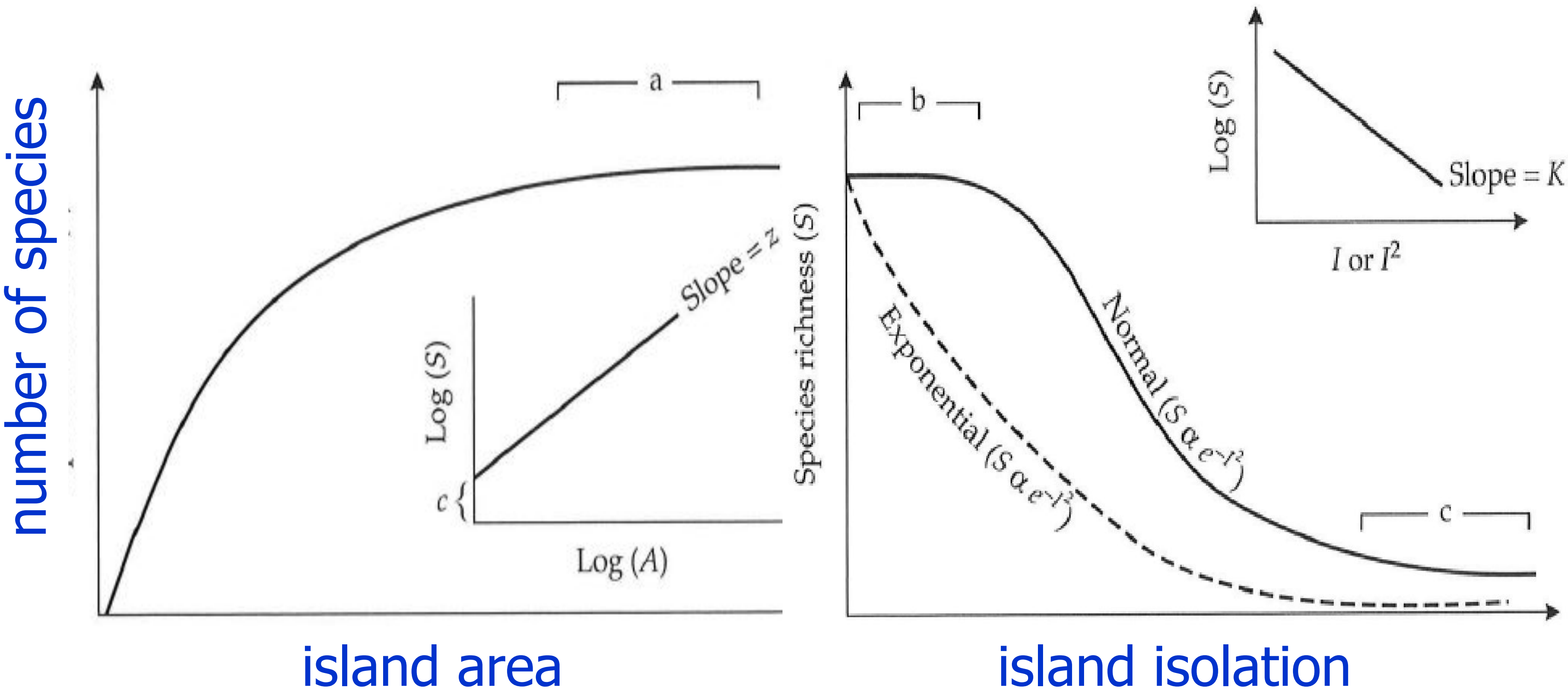




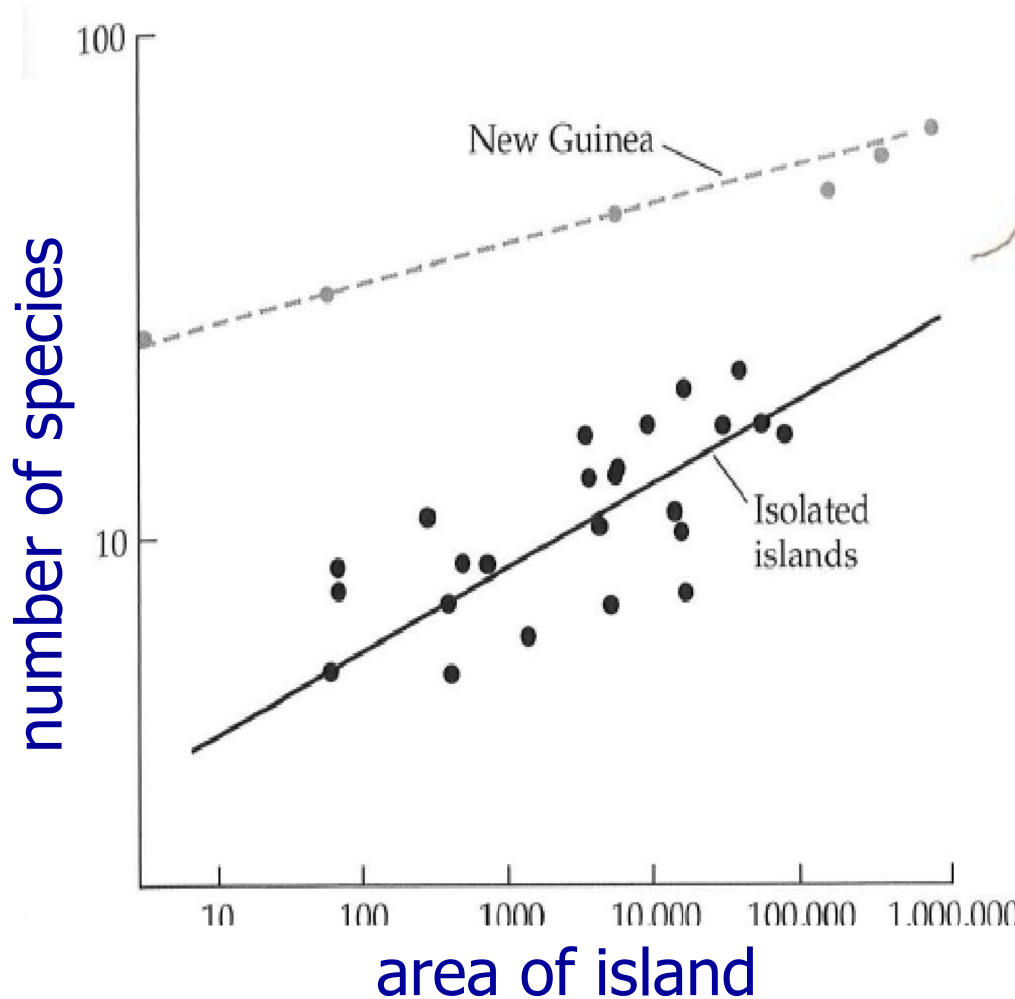


island area

Number of species vs. island isolation



Number of species decreases with island isolation



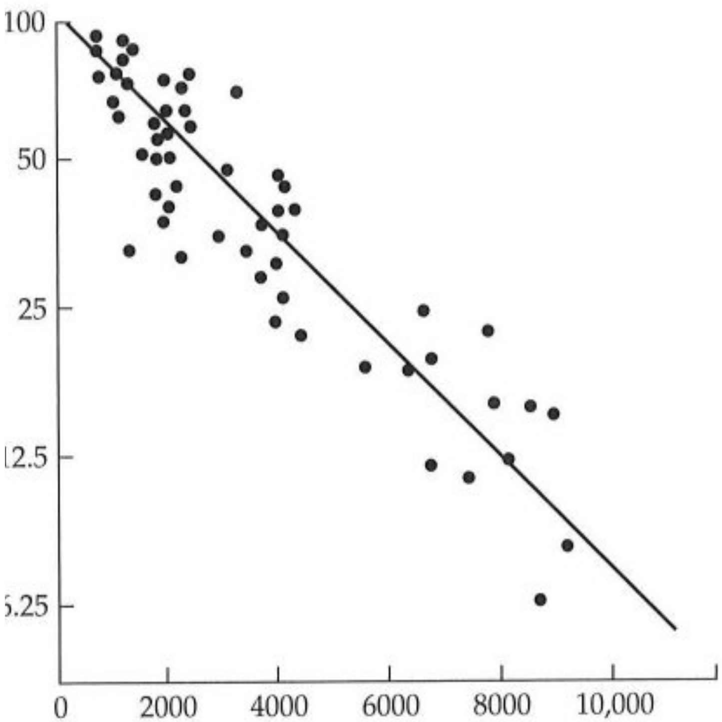
Wilson (1961)

Number of species decreases with island isolation

nonmigratory birds

Melanesian Archipelagos

saturation (%)

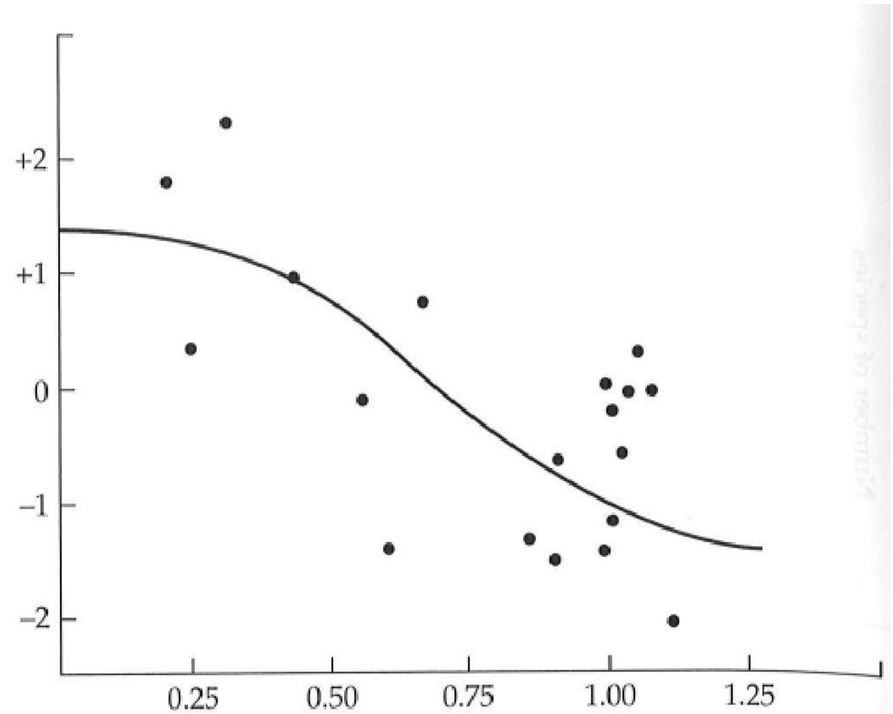


distance from N. Guinea

nonflying mammals

river of St. Lawrence (NY)

residuals

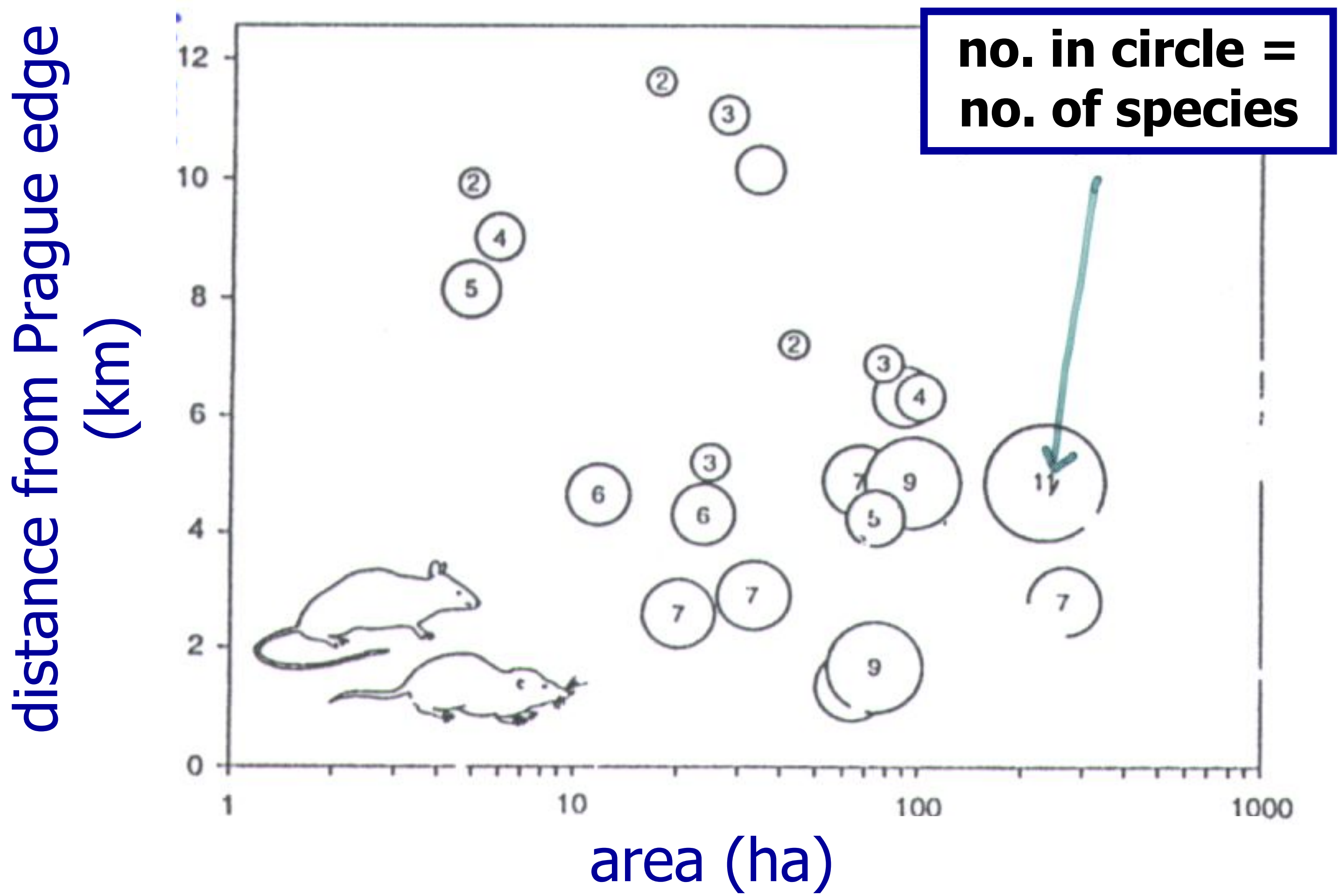


distance

The effect of area and distance

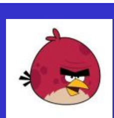
Prague parks

Frynta et al. (1992)



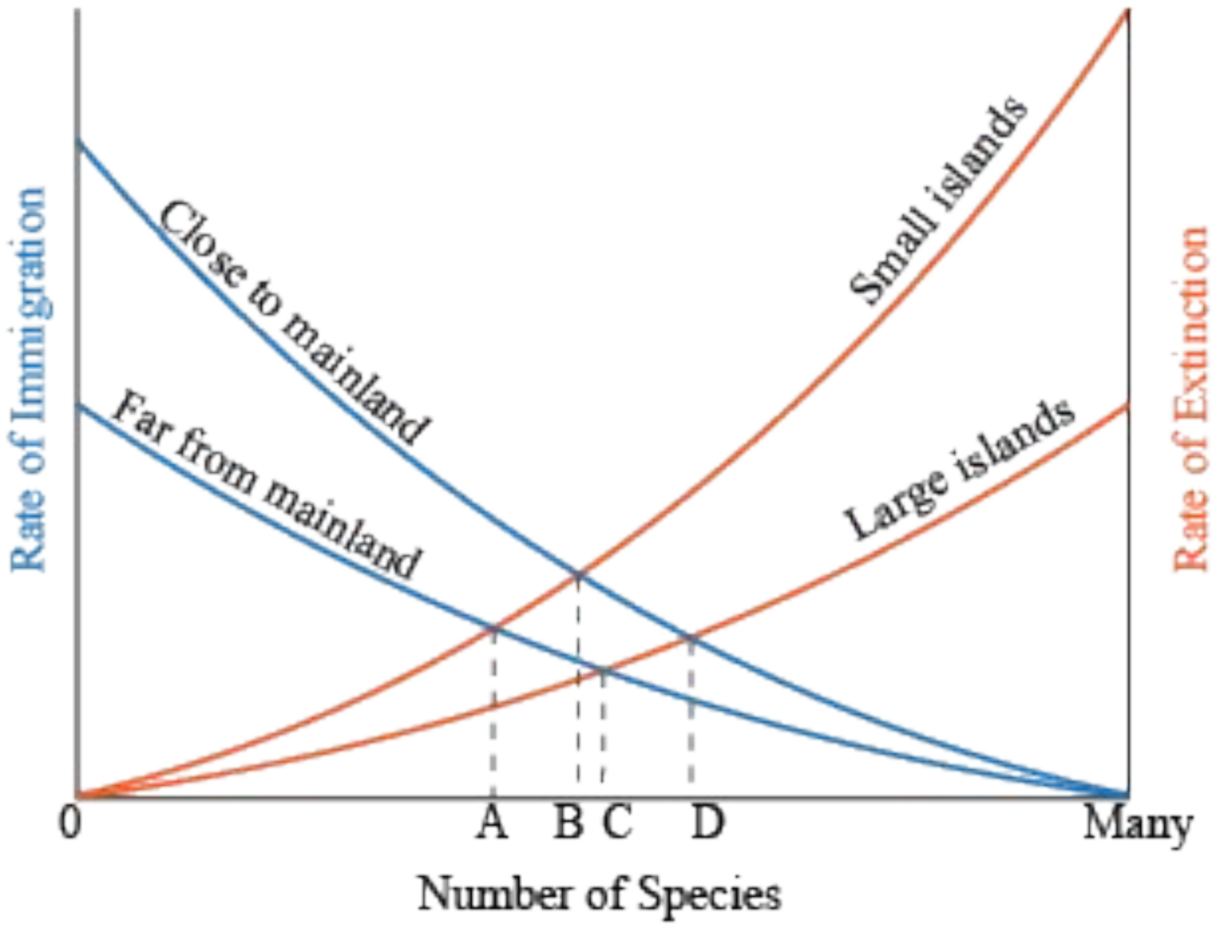
Rate of colozation is higher in the first period

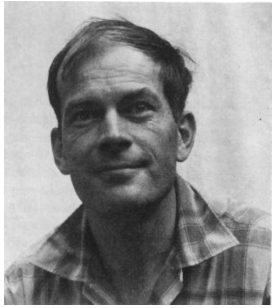
Krakatua
1883

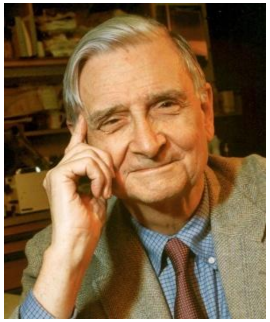
	Rakata		Sertung	
	extinction	colonization	extinction	colonization
1908-1920	2	20	0	28
1921-1934	5	4	2	7

Equilibrium model

MacArthur & Wilson (1963)







Equilibrium model

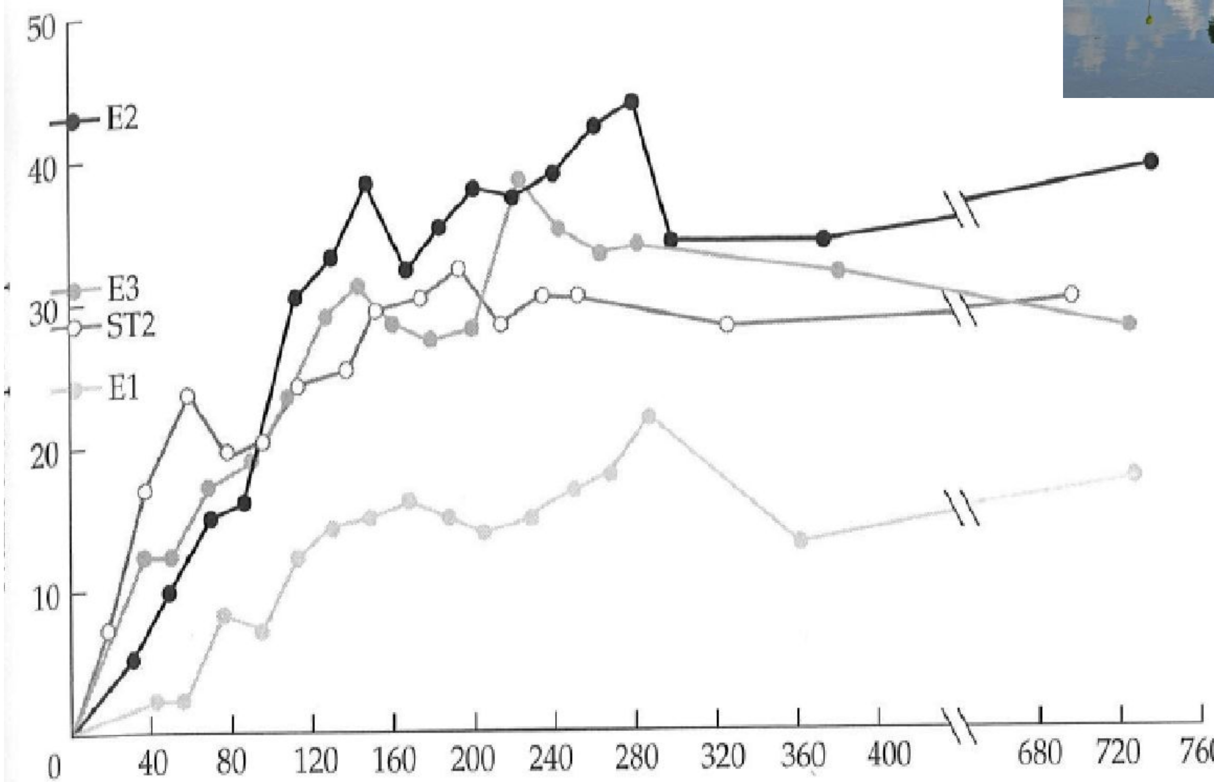
- applied to **islands** and **habitat islands**
- primary succession, **ecological time**
- effect of **island area**, **distance** from source area (mainland)
- species abilities of **colonization** and **susceptibility to extinction** are similar
- applied to species number

Support of equilibrium model

Simberloff, Wilson (1970)

invertebrates

number of species



number of days after invertebrate removal

Support of equilibrium model?

Dimond (1969) turnover of birds in California Channel

Island	Area (km²)	Distance to mainland (km)	Number of species 1917	Number of species 1968	Extinctions	Introductions (by humans)	Colonizations	Turnover (%)
Los Coronados	2.6	13	11	11	4	0	4	36
San Nicholas	57	98	11	11	6	2	4	50
San Clemente	145	79	28	24	9	1	4	25
Santa Catalina	194	32	30	34	6	1	9	24
Santa Barbara	2.6	61	10	6	7	0	3	62
San Miguel	36	42	11	15	4	0	8	46
Santa Rosa	218	44	14	25	1	1	11	32
Santa Cruz	249	31	36	37	6	1	6	17
Anacapa	2.9	21	15	14	5	0	4	31

- raptors included
- secondary succession is not considered
- saturation point?

Criticisms of equilibrium model

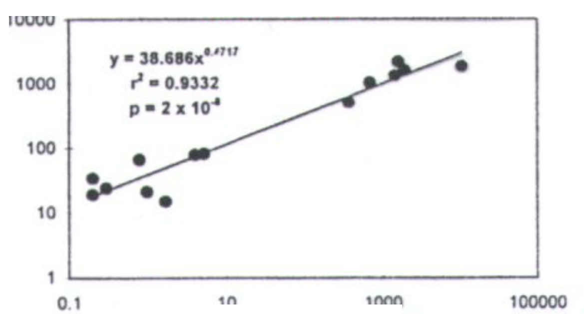
- species **abilities** are not similar
- effect of *succession*, *anthropogenic factors*, *disturbances* are not included
- isolation effect simply like „**stepping-stone**"
- **habitat heterogeneity** is not included
- **speciation** is not considered
- **disturbances** is not considered => EP never achieve

Short conclusion

- the equilibrium for number fo species is affected by **island area** and **isolation**
- the equilibrium model is true for **homogenous** areas and
- applied to species which colonize easily new areas and need large area for surviving

Species number increases with habitat heterogenity

Σ origin sp.

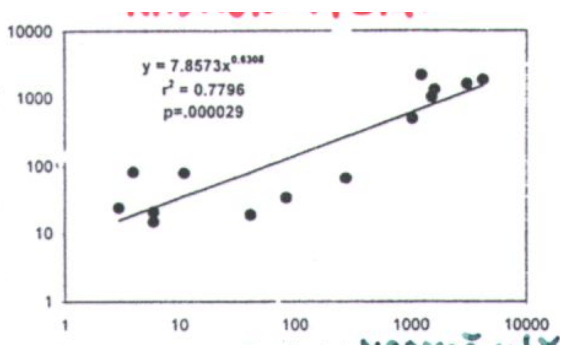


area

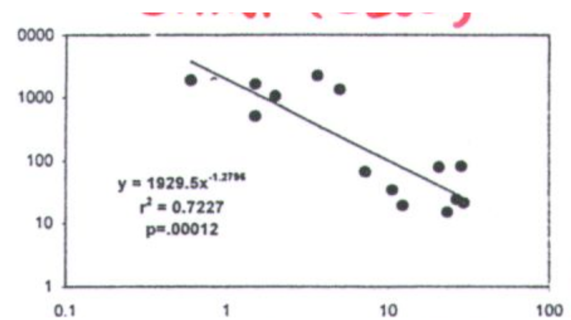
Hawaiian islands

insect

Σ origin sp.



latitude

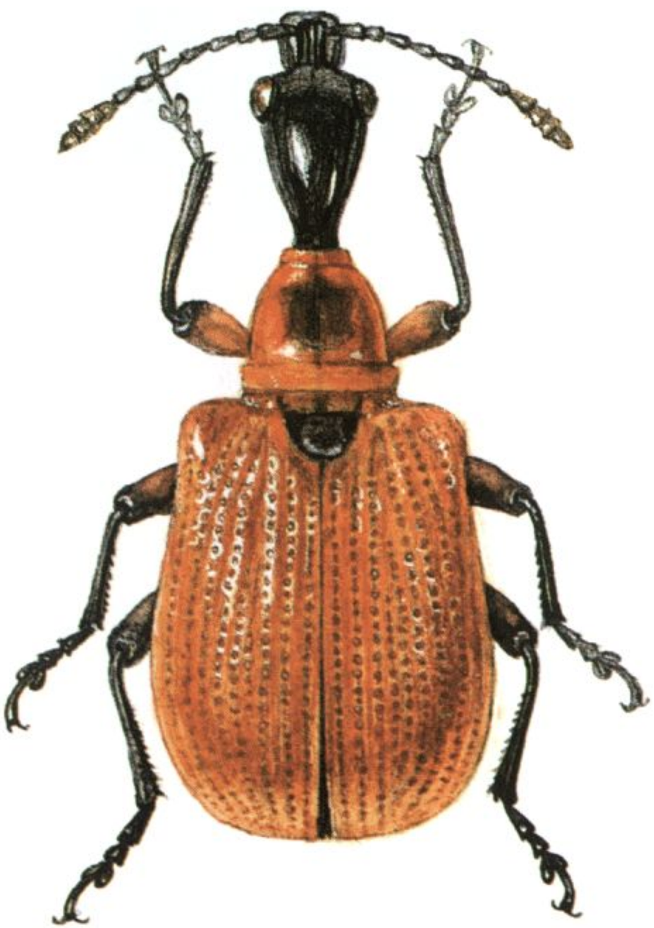


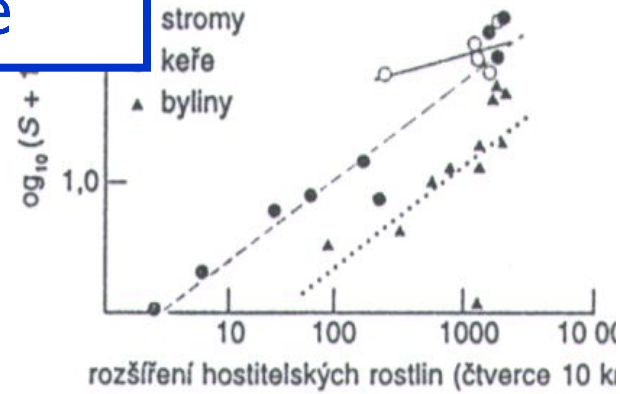
age

Peck et al. (1999)

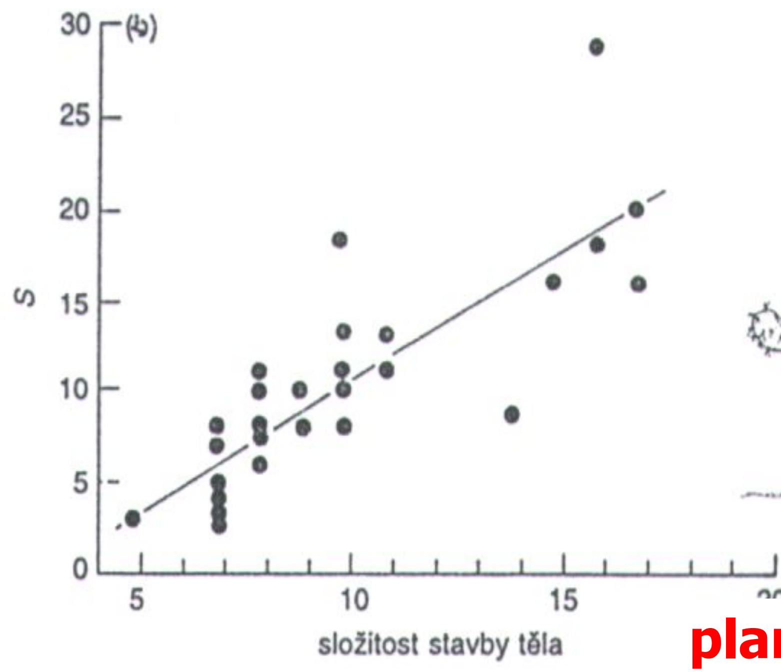
Richness of herbivore insect increases with effect of plant structure

BYLOŽRAVÝ HMYZ





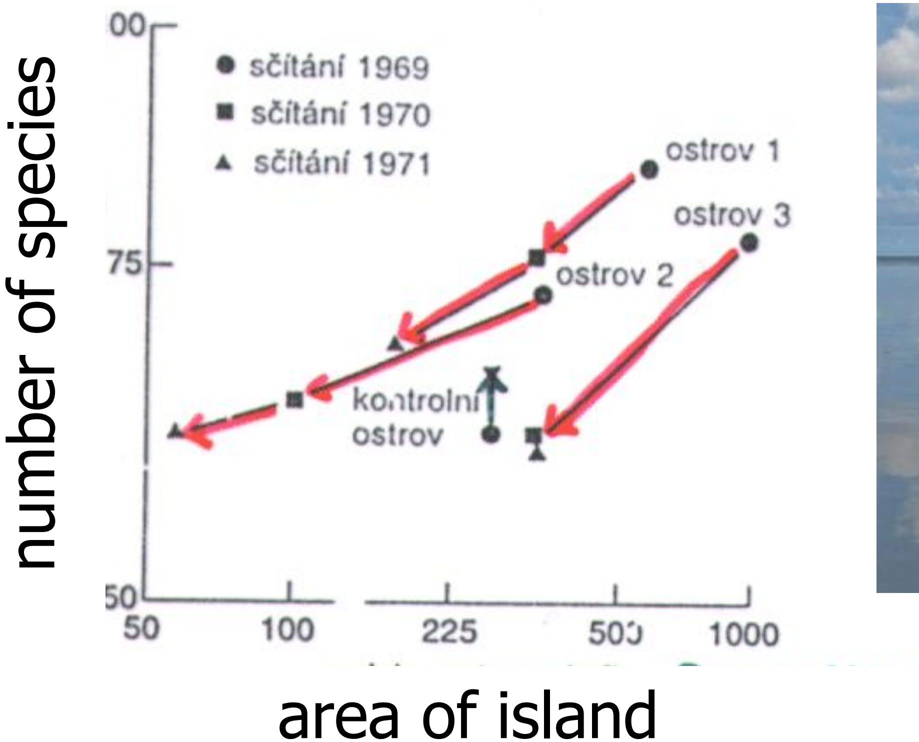
plant abundance



plant structure

Species number decreased with island size

invertebrates



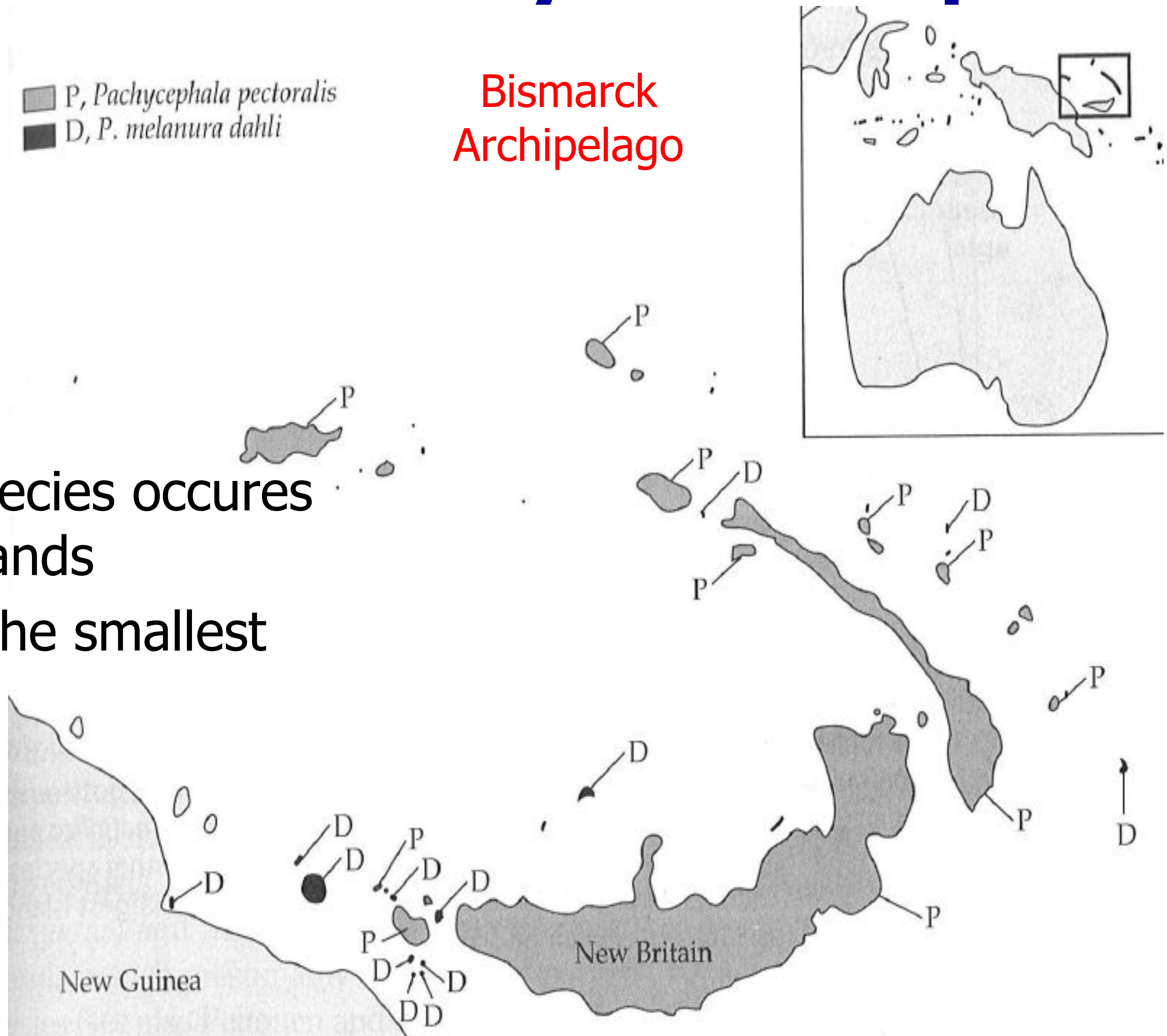
Simberloff (1976)

Evolutionary point of view is more realistic

particular species have **different characteristics:**

- **dispersion** abilities
- **competitive** abilities
- susceptibility to **extinction** and **speciation**

Competition of two flycatcher species



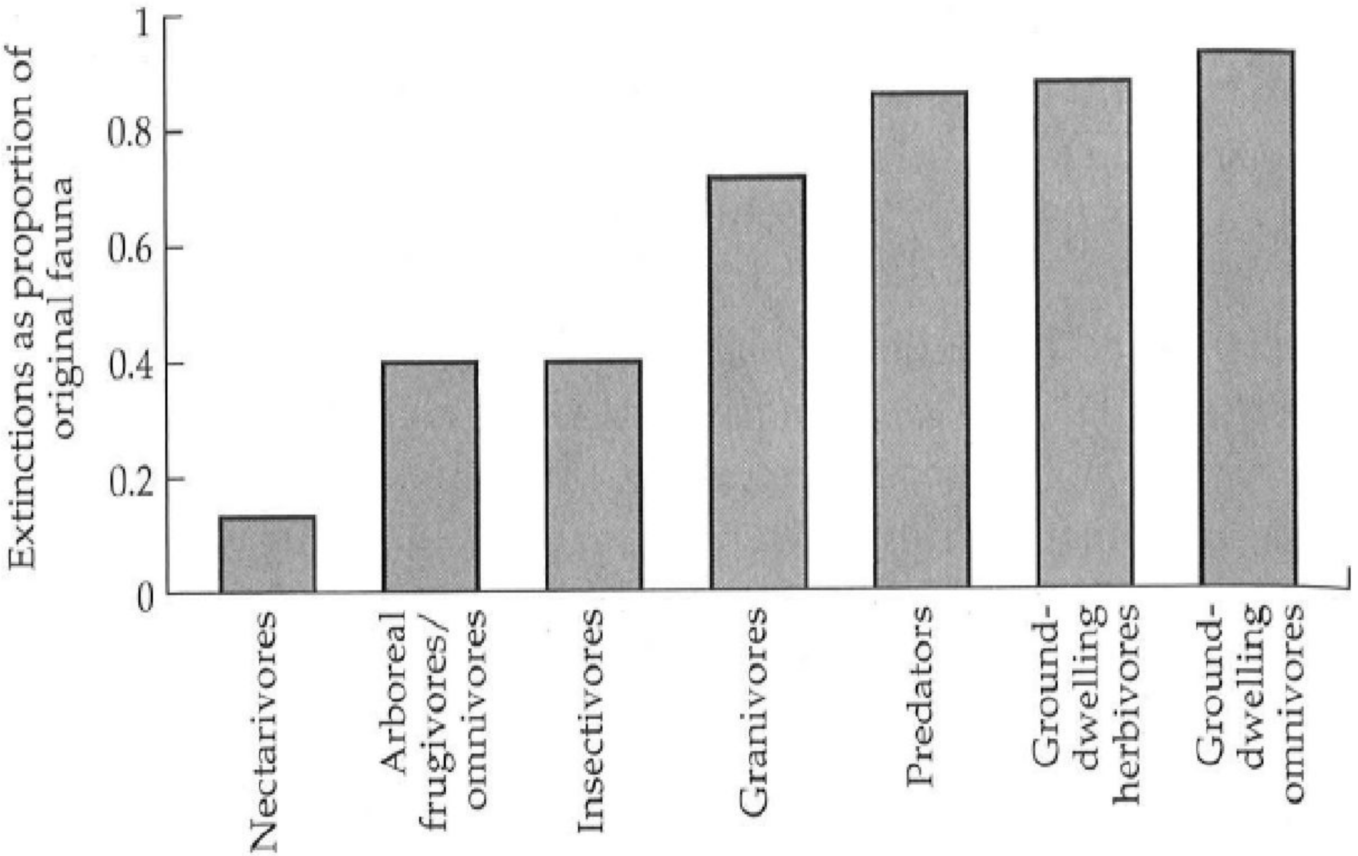
- only one species occures on most islands
- no one on the smallest

High susceptibility to extinction have

- predators, parasites
- organisms with narrow ecological niche

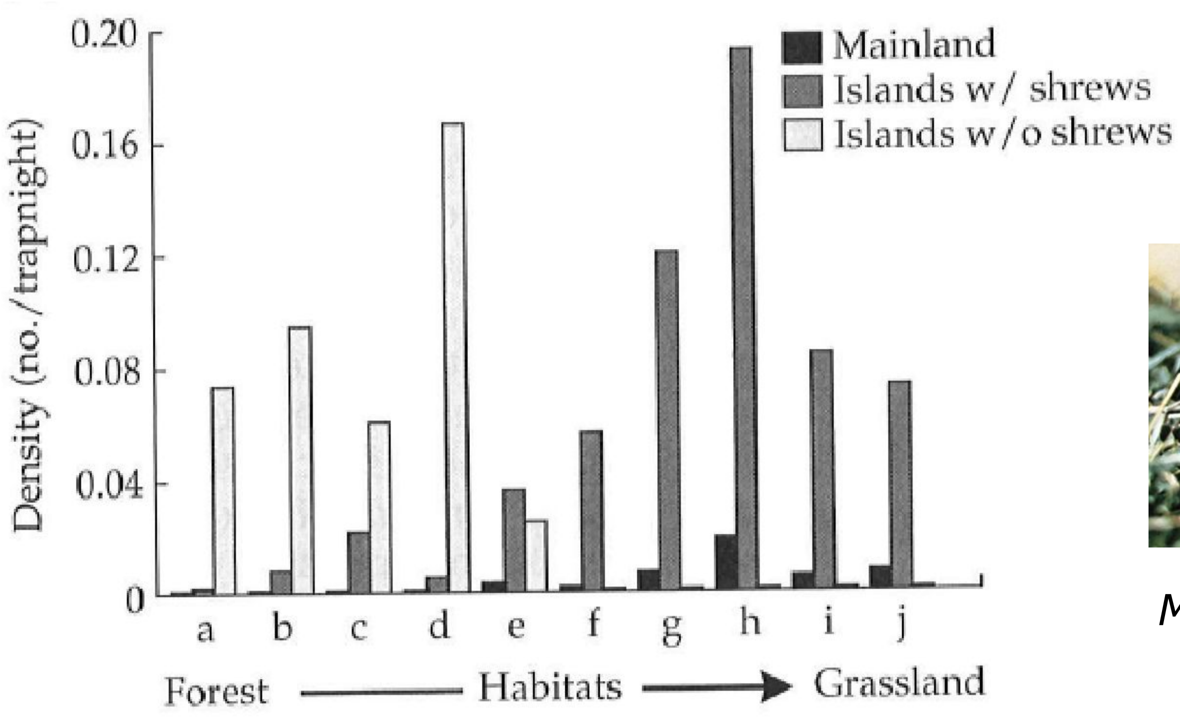
birds

Hawaiian Islands



Ecological release causes niche shifts

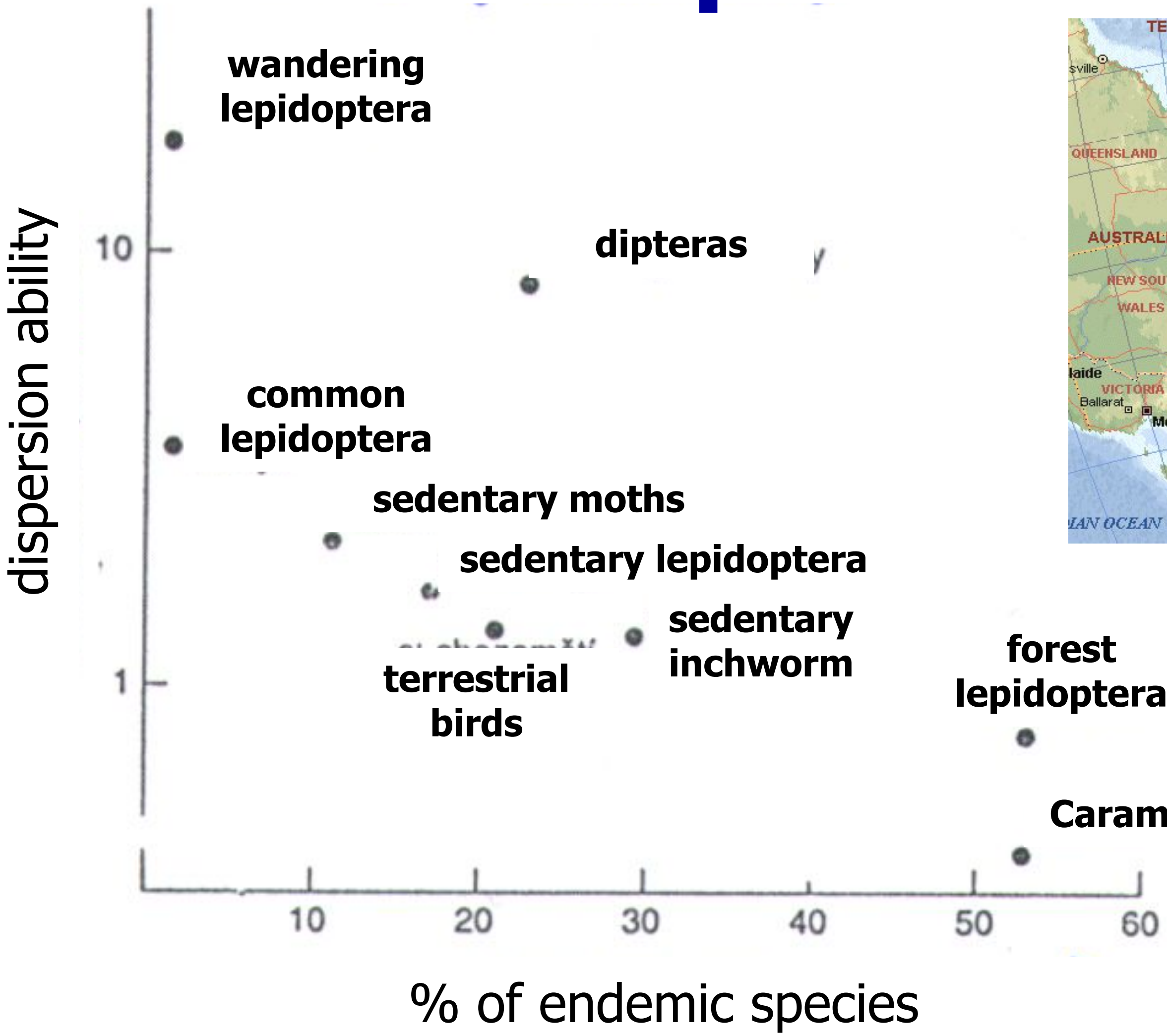
Thousand I., St. Lawrence river (NY)

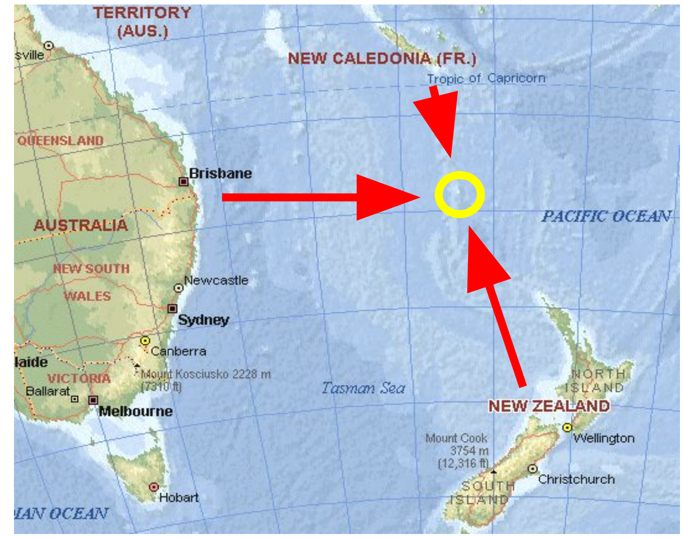


Lomolino
(1984)

Microtus pennsylvanicus

Proportion of endemic species is related to dispersion abilities



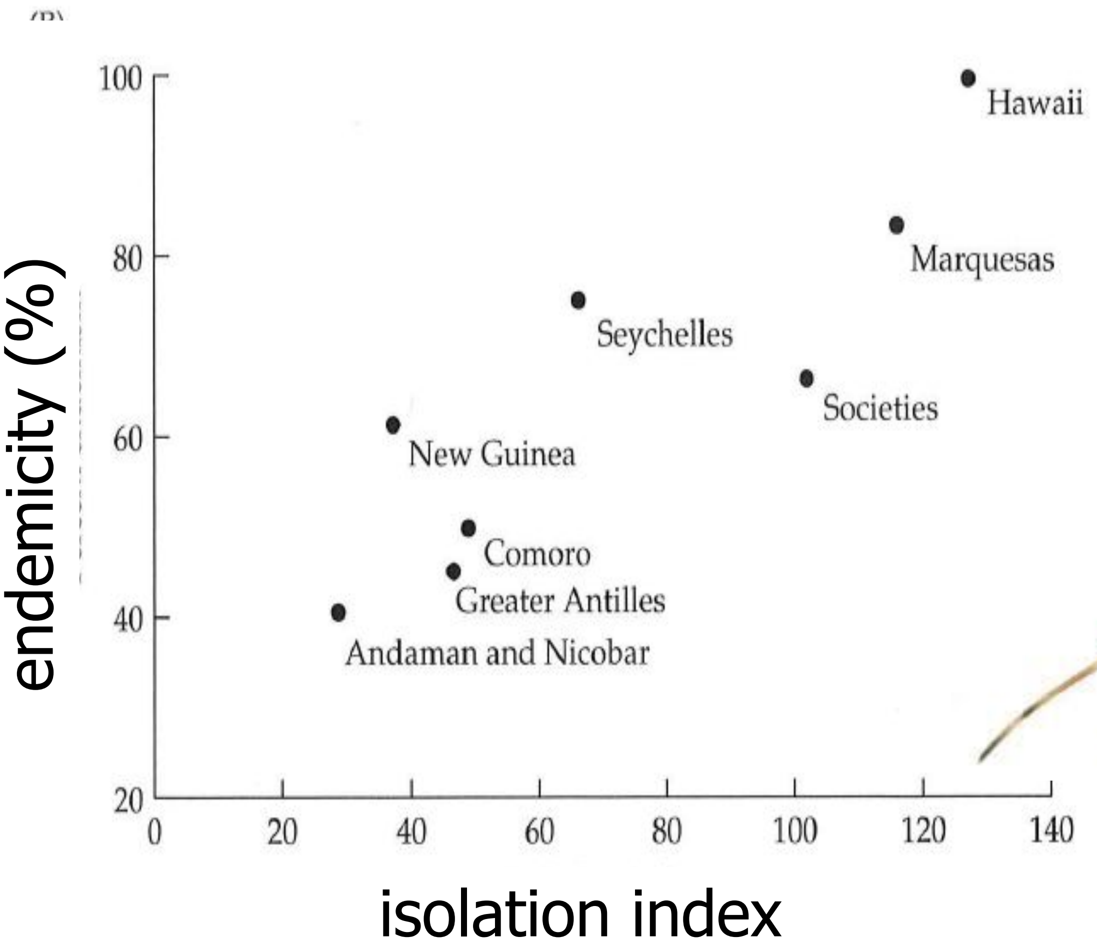


acording to Begon et al. (1997)

Endemism increase with island isolation

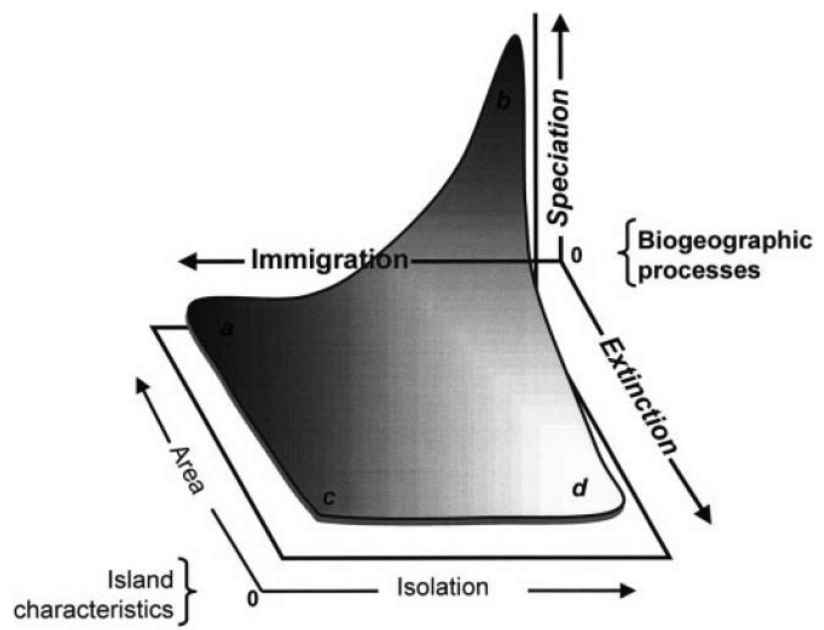
spiders (*Tetraghnatha*)

Pacific Ocean



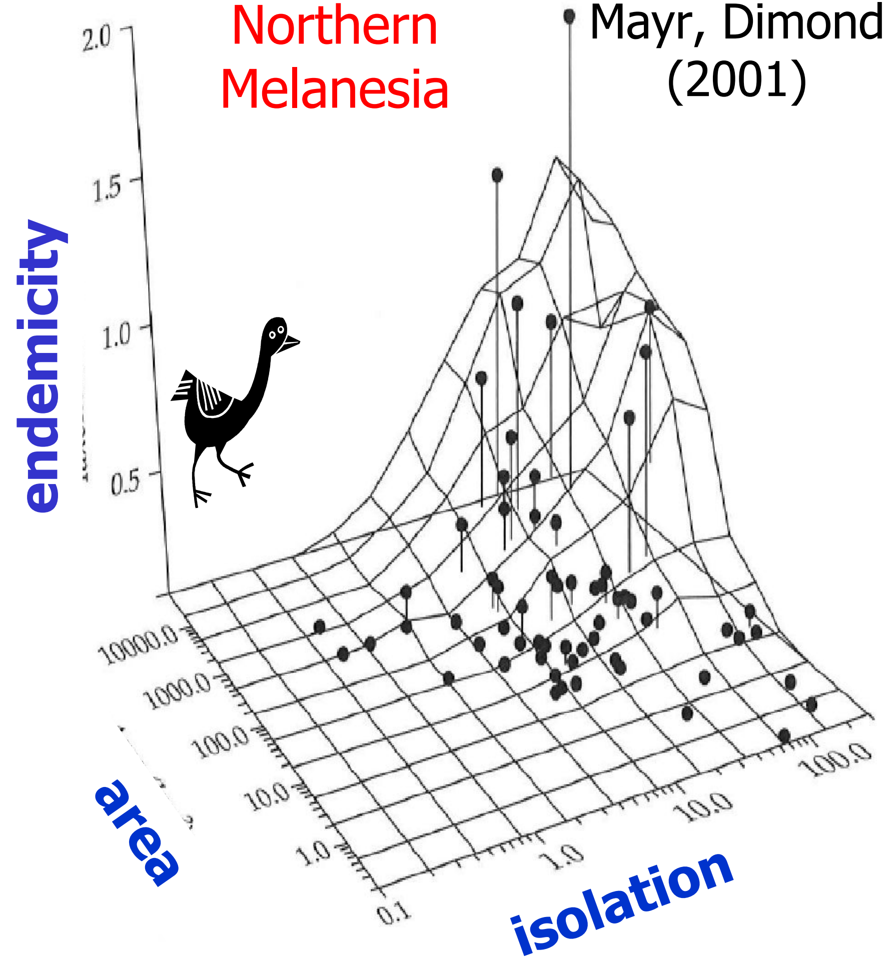
Endemismus increses with island isolation and area

Lomolino (2000)



Northern Melanesia

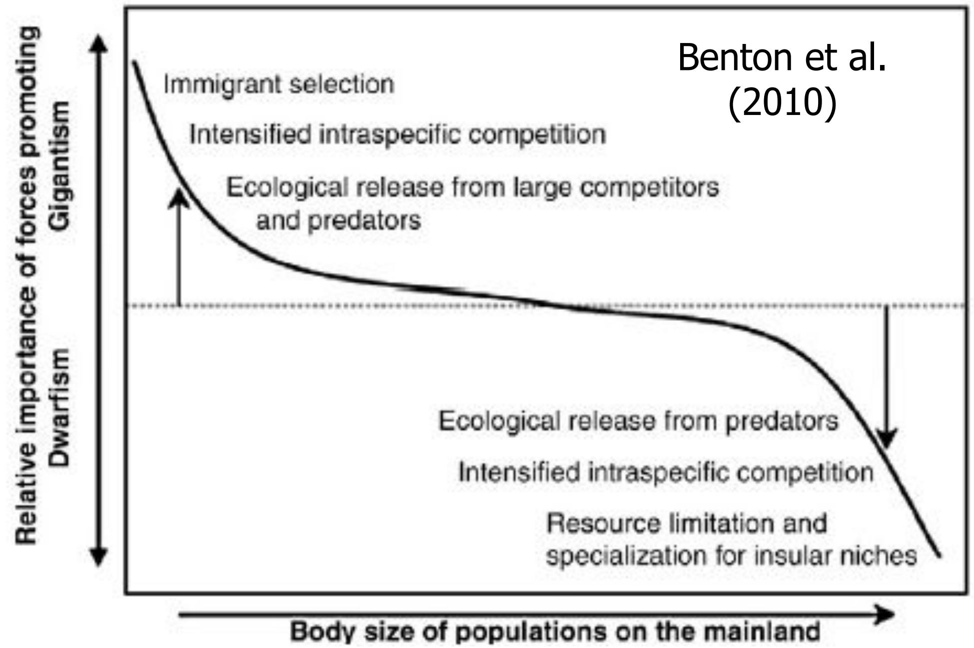
Mayr, Dimond (2001)

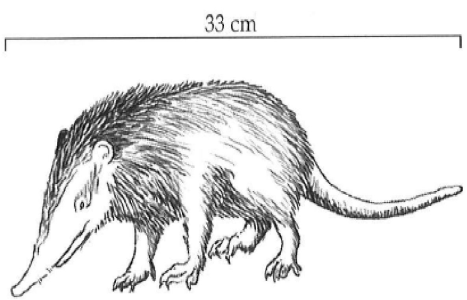


Evolutionary trends on islands

- gigantism, dwarfism
- loss of dispersion

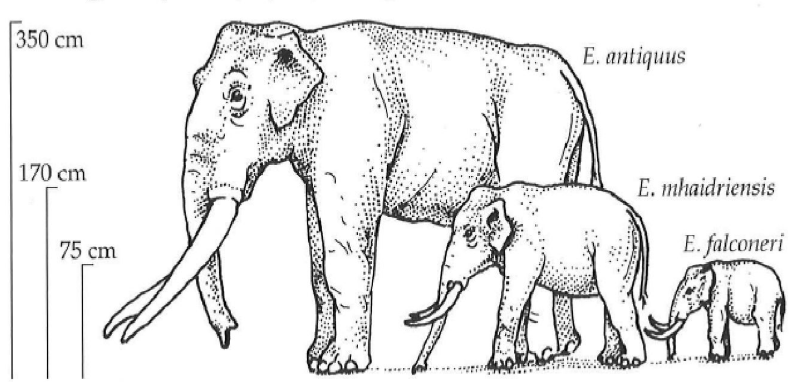
extinct dodo
Mauritius I.





„insular shrew" 1 kg

Dwarfing in Elephants (*Elaphus*) during the Pleistocene



Next evolutionary point of view

(Gillespie & Roderick 2002)

- by **fragmentation** (***fragment*** *islands*)
- **new** formed (***Darwinian*** *islands*)

Fragmented islands

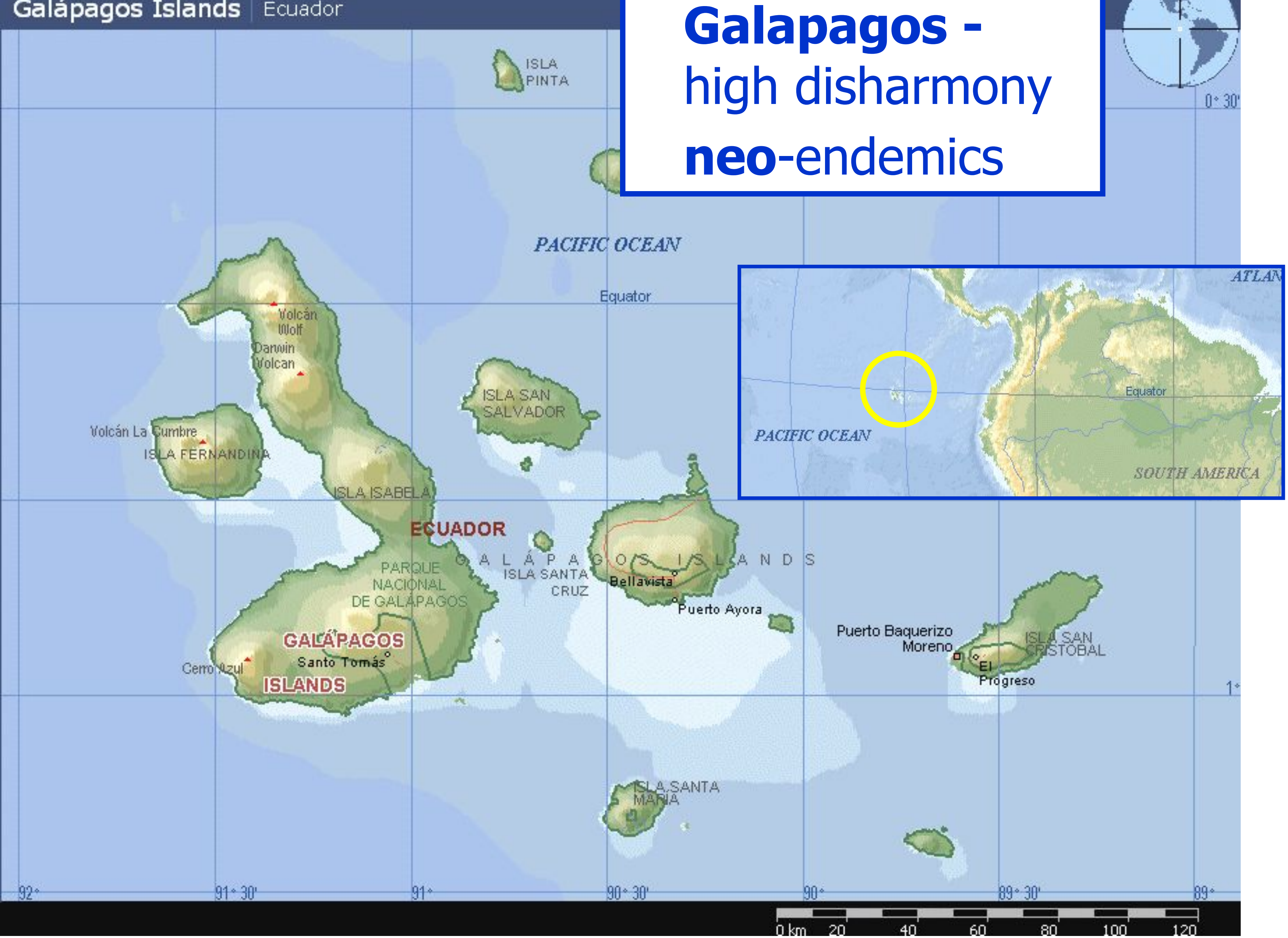
- diversity of already formed community **decreases** due to area reduction (**relaxation** process)
- low success of new **colonists**
- **low disharmony** in proportion of particular group
- speciation: **paleo-**endemics are developed from original species line

Madagascar –
low disharmony
paleo-endemics

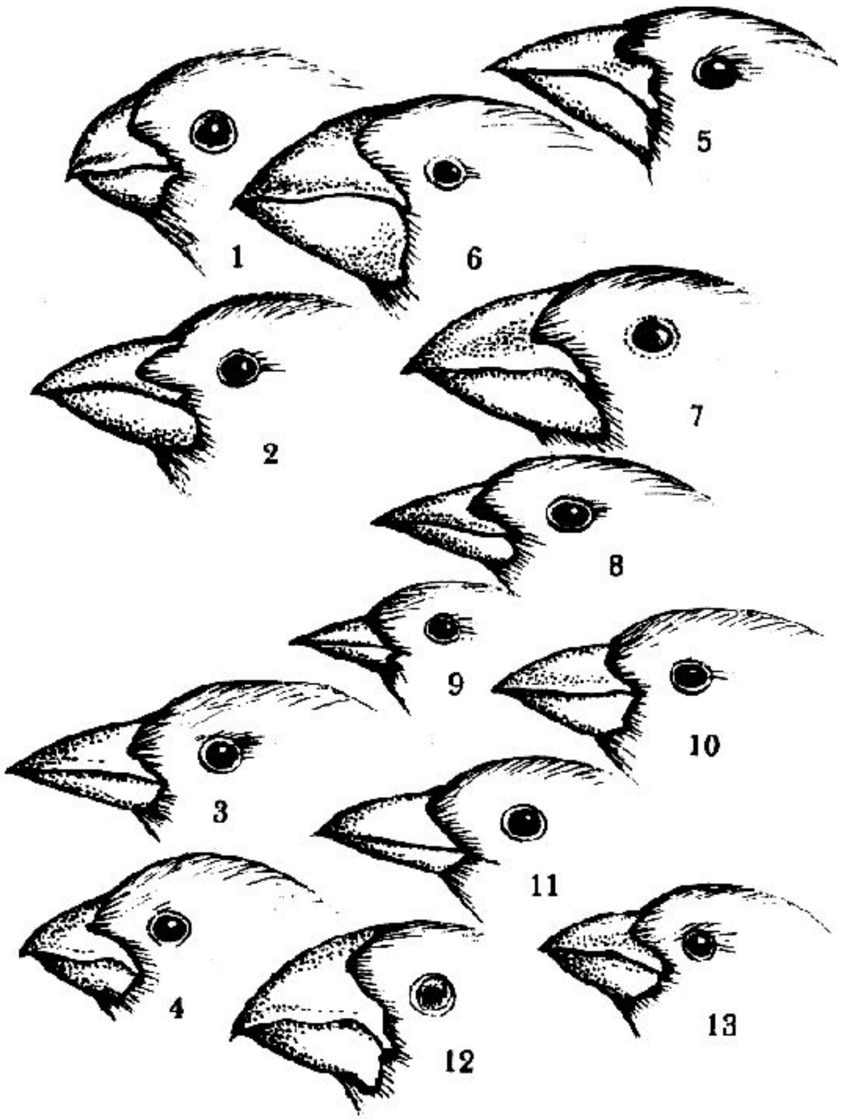
New formed, Darwinian islands

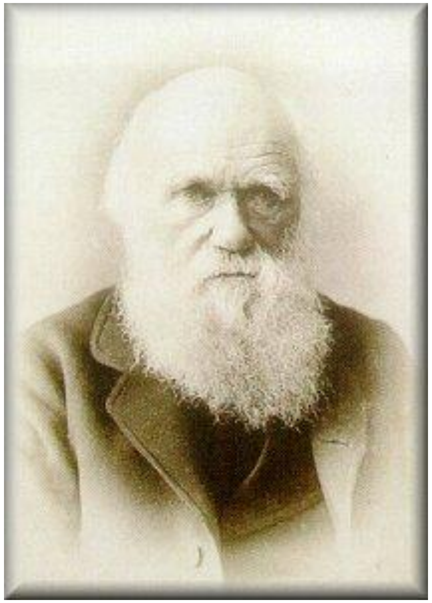
- diversity of new formed community increase –**colonization**
- *high* success of **new colonists** shortly after island origin
- high **disharmony** in proportion of particular group
- speciation: **neo**-endemics are formed from colonist lines, **adaptive radiation** is frequent

Galapagos - high disharmony **neo**-endemics



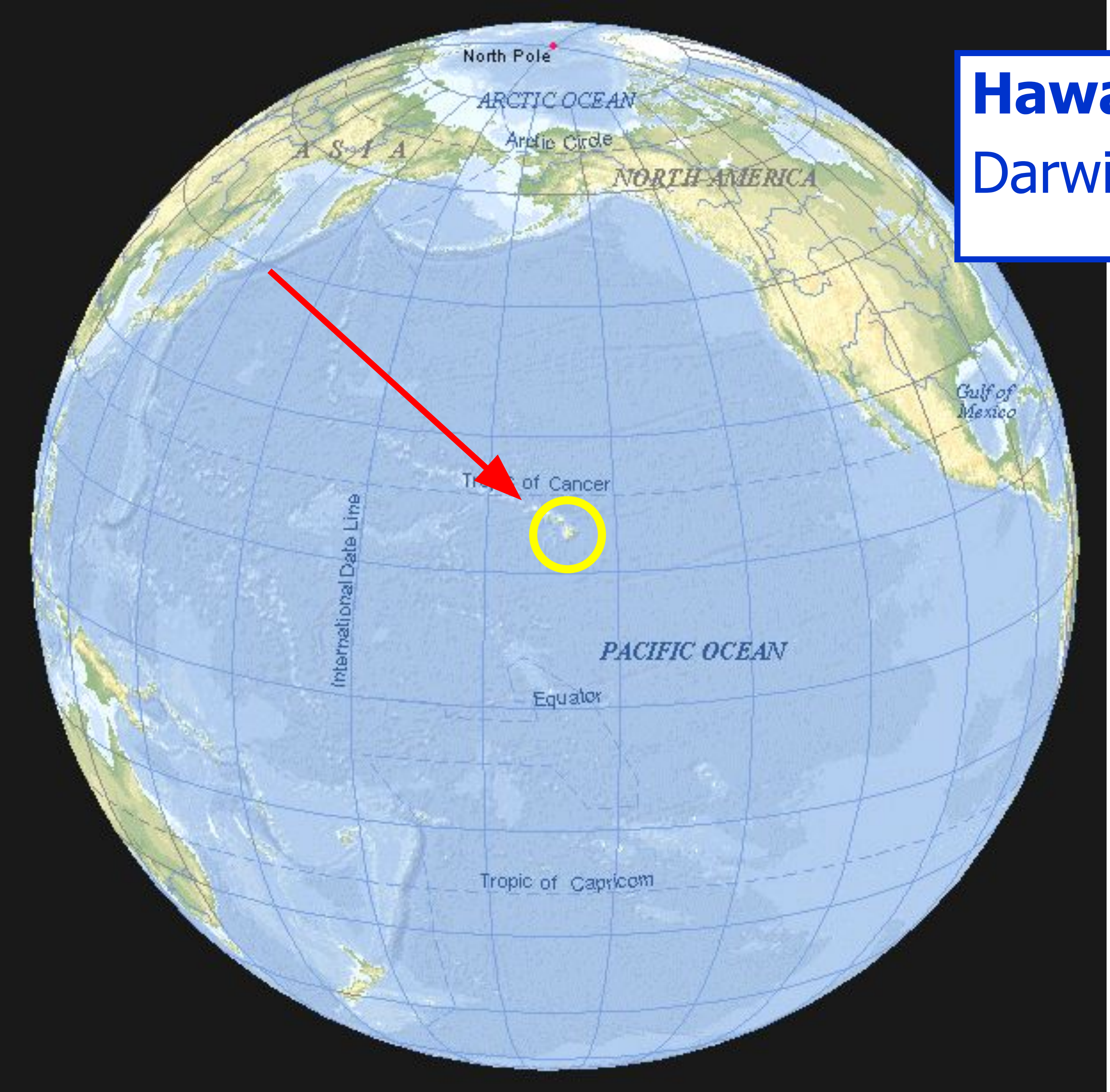
Adaptive radiation of
„Darwinian finches" (Geospizidae family)



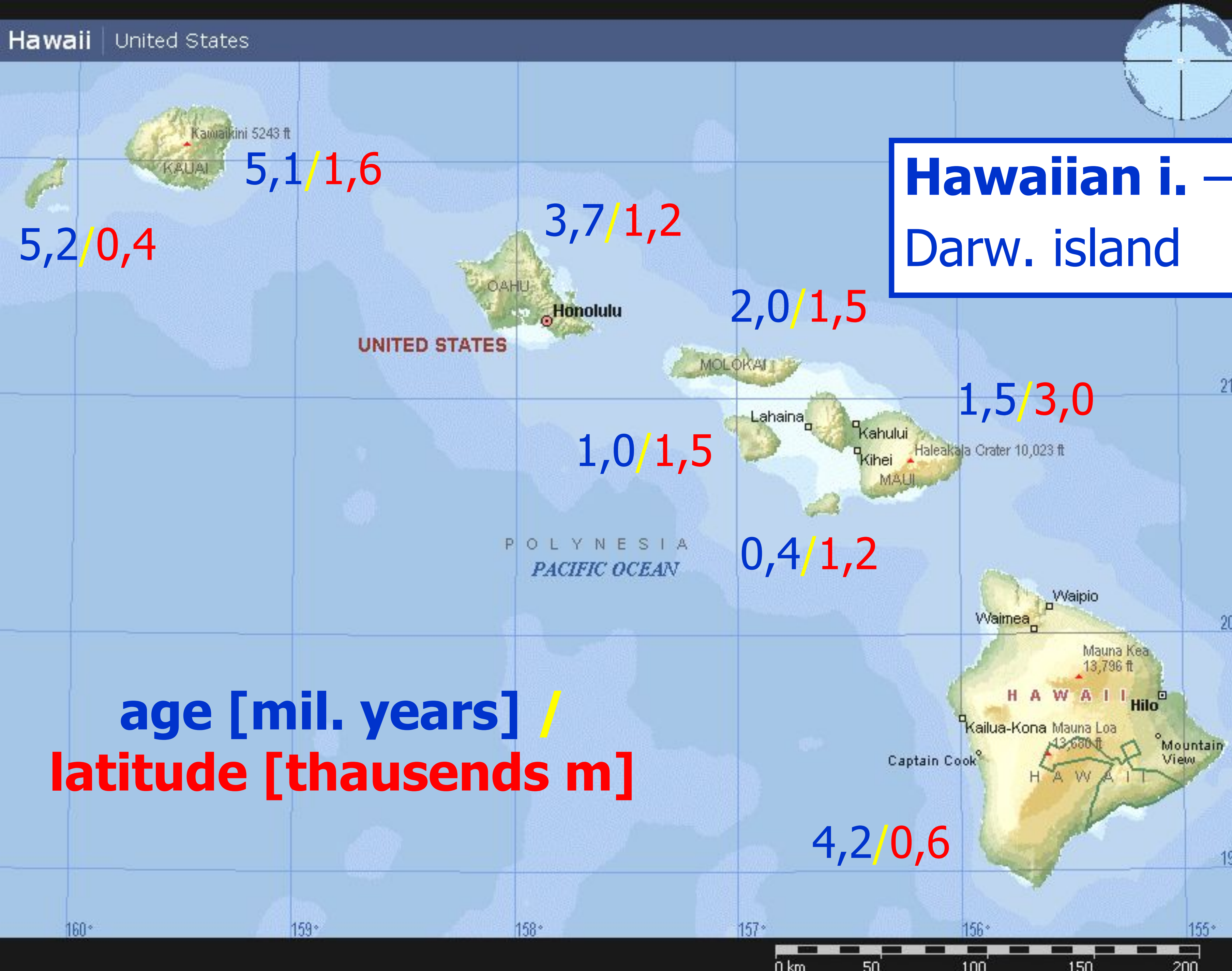


- founder species from S. Am.
- speciation, adaptive radiation
- **neoendemics**

Hawaiian I. –
Darwinian. island

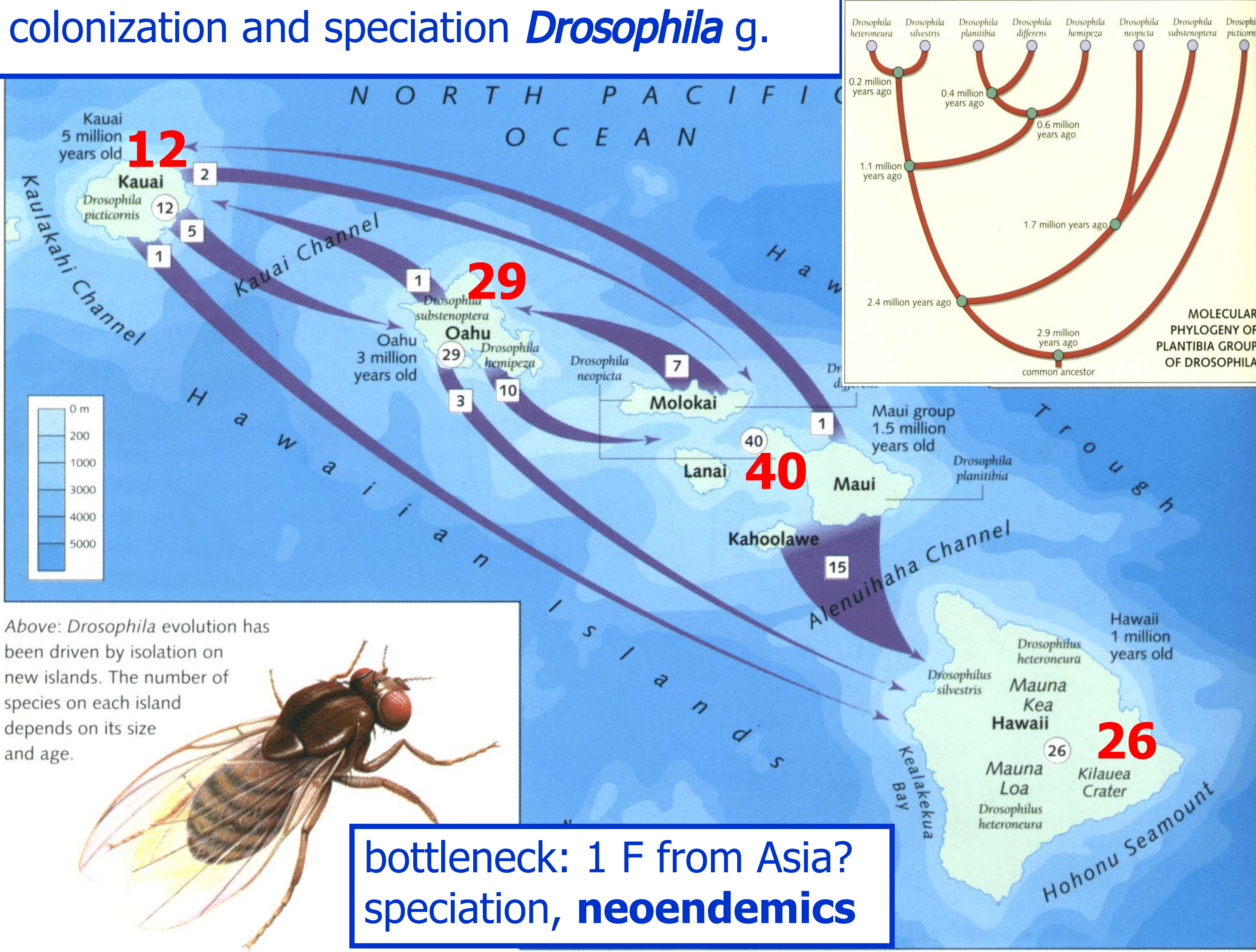


Hawaiian i. – Darw. island



age [mil. years] / latitude [thausends m]

colonization and speciation *Drosophila* g.



Above: *Drosophila* evolution has been driven by isolation on new islands. The number of species on each island depends on its size and age.

bottleneck: 1 F from Asia?
speciation, **neoendemics**

New Guinea –
island of mixed origin

Islands of mixed origin

- examples – **New Guinea, Seychelles I.,** probably **New Zealand** too
- long isolation, occurrence of **paleo-** and **neoendemic** species

Application in nature conservation

- **reservation** = „island" surrounded by „ocean" habitats poorly penetrable for many species
- formed by **fragmentation**
- to maintain **minimal population size** for sufficient genetic diversity
- various *demands* of species
- reflect demands of **key species**
- **habitat diversity**

Application in nature conservation

- species diversity is higher in group of several **small reserves** („archipelagos“), more resistant to epidemic
- choice between conservation of area or species
- effect of **biocorridors** – *immigration* avoid local extinction (short isolation in most reserves = no speciation)

Conclusion

- why insular communities are **poorer**
- **equilibrium** model
- effect of **habitat heterogeneity** on island community
- effect of **species abilities** on diversity of insular communities (*dispersion*, *speciation*, *extinction*)
- effect of **island origin** on insular communities
- application in nature conservation

References:

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