

Species and Speciation

II

by
Dr. Evil

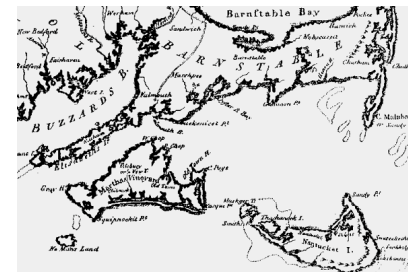
Allopatric speciation, revisited

- Populations are split by *dispersal* or *vicariance*.
- Separated populations may be subject to different selective pressures.
 - Alleles in one population cannot now be exchanged with the other (we say that *gene flow* is blocked). . .
 - One population may also have an unusually high or low frequency of certain alleles, purely by “luck of the draw” — this is the *founder effect*.
 - If a population suffers a crash, survivors may have different allele frequencies, again by chance—this is a *genetic bottleneck*.
- Given enough time, the separated populations diverge into separate species.

An example of the founder effect: *Porphyria* is a human disease that can cause skin lesions, digestive problems, and mental disturbances. One form of porphyria happens to be unusually common among South Africans of Dutch descent—because, among the small Dutch population that settled there, one member (Ariaantje Adriaansse, an orphan girl who was shipped over in 1688) happened to be carrying the allele.



Another example: Congenital deafness in 19th-century America affected about 1 in 5700 people. But on the island of Martha’s Vineyard, off the Massachusetts coast, the incidence was as high as 1 in 155 (in one town, it was 1 in 25). Reason: A few of the colonial settlers were either deaf or carriers of the allele—and until recently, Martha’s Vineyard was rather culturally isolated from the mainland.



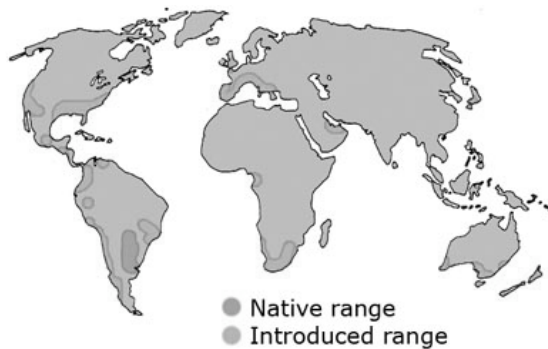
In its native South America, the Argentine ant (*Linepithema humile*) lives in colonies—and ants from genetically different colonies attack each other, because they sense different hydrocarbons on each other's exoskeletons.



L. humile has been introduced to California, Europe, and Japan—and there, in part because of the founder effect, all ants are so genetically similar (at least in the genes involved in recognition) that they don't attack each other.



Instead, they form *supercolonies*—sets of interconnected, multi-queen colonies that can freely exchange workers. The largest extends 6000 km (3600 miles) along the Mediterranean coast.



An example of a bottleneck: *Achromatopsia* is the complete or near-complete inability to see any colors. It's extremely rare worldwide (1 in 33000 people in the US). But on the tiny island of Pingelap in the Pacific Ocean, almost 10% of the people are affected.



This is partly due to inbreeding, but also due to a typhoon and crop failure in 1775 that reduced the population to 20—one of whom (the chief) just happened to be a carrier of achromatopsia!

Adaptive Radiation

- Founder species encounters new, unoccupied ecological niches. . .
 - . . . and rapidly speciates into a large number of closely related species occupying different niches: a *species flock*.
 - Some classic examples:
 - Galápagos finches (14 species)
 - Hawaiian honeycreepers (52)
 - French Polynesian land snails (120)
 - Hawaiian fruit flies (700+)
 - African Rift Valley cichlids (1000)

Hawaiian Honeycreepers

- Hawaii is 2000 miles from nearest mainland
- One group of birds, the honeycreepers (Drepanidinae) have undergone an adaptive radiation (52 species, about half now extinct and most of the rest endangered)
 - Different beak types
 - Different food supplies (usually nectar of native flowers, sometimes insects, seeds, fruits)
 - Parallel to the Galápagos finches in many ways



Vestiaria coccinea (ʻIiwi)



Himantione sanguinea (ʻApapane)



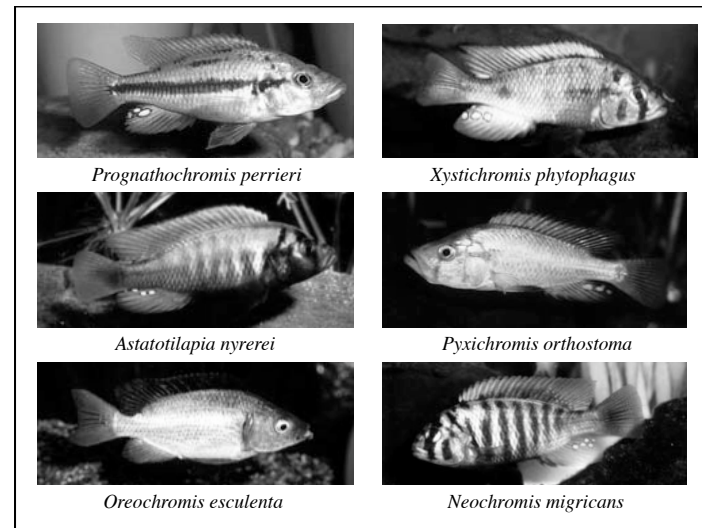
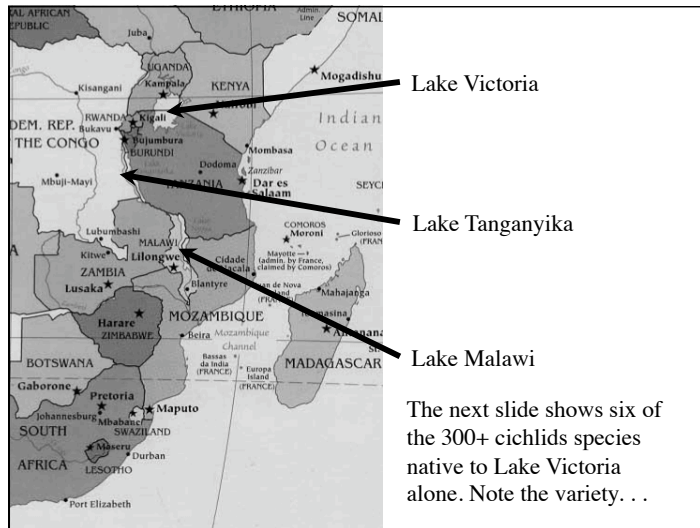
Hemignathus munroi (ʻAkiapolaʻau)



Palmeria dolei (ʻAkohekohe)

African Rift Cichlids

- Lake Victoria in East African Rift valley contains 300 species of *cichlid* fish.
 - Actually. . . it *did*, before humans introduced predatory the Nile perch, which ate most of them. About 200 species of cichlid are probably extinct now.
- Other lakes, especially Tanganyika and Malawi, contain similar flocks of cichlid species
 - Total: 1000 species in all the East African lakes, some of which are popular in the aquarium trade



How fast?

- Lake Victoria completely dried up 12,400 years ago. (How do we know? There's a "fossil soil" layer under the silt of the lake.)
 - The 300 species of cichlids in Lake Victoria must have descended from a common ancestor in less than 12,000 years. (Yow!)
 - A small lake, Lake Nabugabo, has been separate from Lake Victoria for only 4,000 years—yet it has five cichlid species found nowhere else
 - Plausible case of *peripatric* speciation: when lake is low, isolated ponds may form around perimeter.

But what is a *species*?

- Bottlenecks and the founder effect don't have to cause speciation (in the human examples you saw last week, they have not).
- But if two populations are separated permanently, bottlenecks and the founder effect can contribute to genetic divergence and thus the formation of new species.
- But. . . *what's a species?*

In part to try to handle some of the difficulties of the BSC, some alternative concepts have been proposed, but they aren't flawless either.

- Biological species concept—defines a species by inability to interbreed with others
- Morphological species concept—defines a species by its unique features
- Ecological species concept—defines a species by the niche it inhabits
- Behavioral species concept—defines a species by its *SMRS*—*specific mate recognition strategy*

Case Study: Eastern Toads

- Albert Blair (1941) studied the ability of different populations of different toad species to interbreed
- The following summary of some of his findings deals with two toad species which overlap in distribution, *Bufo americanus* and *B. fowleri*. (This is only a small part of his total findings.)
 - Source: Blair, A. P. 1941. Variation, isolating mechanisms, and hybridization in certain toads. *Genetics* 26: 398-417.

Blair crossed female *B. fowleri* from Indiana with male *B. americanus* from elsewhere. . .



Bufo fowleri

Bufo americanus

Here's what he got in ten of his crosses:

| <u>Male's locality</u> | <u>% eggs yielding tadpoles</u> |
|------------------------|---------------------------------|
| Bloomington, IN | 40 |
| Bloomington, IN | 44 |
| Bloomington, IN | 60 |
| Bloomington, IN | 95 |
| Winona Lake, IN | 0 |
| Tulsa, OK | 4 |
| Tulsa, OK | 50 |
| Tulsa, OK | 60 |
| Tulsa, OK | 80 |
| Tulsa, OK | 95 |

So are these separate species?

- Behavioral species concept: Probably. *B. americanus* breeds in shallower ponds, earlier in the year, than *B. fowleri* (although there's overlap). The mating calls are also quite different (*B. fowleri* "drones"; *B. americanus* "trills").
- Morphological species concept: Probably not. There are different tendencies (example: *B. americanus* is usually more reddish, with more spots on the belly), but these aren't consistent within each species, and taxonomists have long disagreed about just how to classify these toads.

So are these separate species?

- Ecological species concept: Not really. The two species overlap a great deal, although there are a few differences (*B. americanus* reaches higher altitudes than *B. fowleri*, for example).
- Biological species concept: Hard to say, even though Blair found that at least some of the hybrids turned out to be fertile.
- We'd now tend to call this a *species complex*.