Integrative Biology 200 “PRINCIPLES OF PHYLOGENETICS”

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Biogeography—from Area Homology and patterns to why organisms are where they are—

The field that attempts to document and understand the spatial patterns of organisms in the past and present and develop process explanations and historical scenarios for variation in distribution or seeks a natural classification of areas.

Like other areas of science this discipline is looking for non-random patterns of repetitive organization that are the result of one or a small set of general processes. This, like phylogenetics, assumes a form of uniformitarianism sometimes referred to as actualism, where the kinds of process, e.g., allopatric speciation, dispersal, extinction, that we see now were happening in the past.

Areas:

-Nominal areas, often geopolitical, e.g. California or Yosemite National Park.

-Natural areas, either geological or ecological areas that can be treated as an individual with a part-whole relationship to the Earth and historical relationships to other such areas.

-Areas of endemism are circumscribed by shared ranges of some number of taxa, usually species, which do not have a worldwide distribution.

Dispersal:

-Ecological dispersal and dispersion, the movement of individuals over the landscape. Not typically correlated with cladogenic events.

-Traditional dispersal, rare or one-time events that can be problematic as ad hoc explanations.

-Geodispersal is geologically mediated dispersal that produces congruent range expansion and subsequent vicariance that correlates to cladogenic events.

Vicariance:

-the splitting of areas that results in the separation of the flora and fauna and allopatry.

Centers of origin:

What are they?

Why are they important or are they important?

What criteria can, or at least has been used to detect centers of origin?

After Cain's (1994) list

1. Location of greatest number of species (taxa)
2. Location of greatest concentration of individuals (dominance)
3. Location of primitive and closely-related forms
4. Location of largest and most robust individuals
5. Location of greatest productivity and stability
6. Center of lines of migration radiating from a location
7. Location of greatest breadth of habitats (least dependence on rare habitat)
8. Center of lines of clinal variation radiating from location
9. Geographical affinity (all southern hemisphere)
10. Annual migration of birds (all species winter in Mexico
11. Seasonal appearance (conserved phenology)
12. Location of greatest number of dominant alleles
13. Greatest number of overlapping distributions

-these sort of criteria were very actively used up to the early 1980s and still persist at least implicitly
-centers of origin and dispersal is very often used to make sweeping statements about innovation and causes of "success"

Darwin, in the Origin:

"*When we feel assured that all the individuals of the same species, and all the closely allied species of most genera, have within a not very remote period descended from one parent, and have migrated from some one birth-place; and when we better know the many means of migration, then, by the light which geology now throws, and will continue to throw on former changes of climate and of the level of the land, we shall surely be enabled to trace in an admirable manner the former migrations of, the inhabitants of the whole world.*"

I. Ecological Biogeography: Looks at present distributions, or distributions at a point in time, and attempts to account for these by looking at interactions among the organisms and their biotic and physical environment.

A. Typically deals with essentially atemporal or relatively recent, short-term patterns (but not exclusively) and interactions with an ecological, physiological and phenological emphasis.

1. From this view, questions addressed might be like "What allows a species to occur in one area and prevents it from expanding into other areas?"

B. Often ecosystem, community or population based, where the entities are part of an ecological hierarchy.

C. Can involve paleontological data, so is not restricted to currently extant populations, (e.g., Eliaset al. 2000)

D. Can be over a large range, e.g. diversity over a latitudinal or elevational gradient.

E. Studies often involve the impact of human activities, succession theory, the dynamics of communities and populations, fire ecology, restoration ecology, invasive species, species pulses or waves, and elements of classic island biogeography.

F. Dispersal is important, but not defining

II. Historical Biogeography: Attempts to reconstruct the patterns of the origin, dispersal and extinction of taxa and biotas and the relationships of areas.

A. Usually involves historical, typically older patterns inferred by looking at clades (often as species and higher taxa that are monophyletic)

1. How species accumulate (or are lost)
2. How biotas come into being
3. How are areas related

B. Focus on why lineages are represented in certain areas and not others and why is a pattern of distributions frequently repeated in different lineages.

C. Typically area relationships and general patterns of diversity are emphasized over single taxon distributions.

III. Brief Historical overview of "periods" and discoveries in historical biogeography

A. At the time of a limited view of dynamics and diversity

1. Creation myths, dispersal from Noah's ark, etc.
2. Little understanding beyond local flora/fauna

B. Age of exploration

1. 17th century led to discovery of too many species for the Ark
2. Realization that environmentally similar but distantly isolated regions have distinct

assemblages of organisms (Buffon's Law)

3. Islands have lower lineage diversity

4. Similar floristic zonation (Humbolt)

C. 19th century, advances in geology and evolutionary theory

1. Lyell, Darwin, Wallace, Sclater, Hooker, etc.

2. Abandonment (by most) of the idea of static distribution and immutability of species.

3. Land bridges/megacontinents (e.g. Hooker, Wallace) vs. dispersal (e.g. Darwin)

D. 20th century

1. Continental drift (Wegener 1912)- but not really accepted until 1960s- (Dietz & Holder 1970) Persistent dispersalists like Simpson and Darlington maintained that even if continents moved dispersal was still more important.

2. Panbiogeography of Croizat, phylogenetics of Hennig and implementation Brundin (1966) for a trans-Gondwanan group of flies

a. Start of phylogenetic biogeography

b. similarity of phylogenetic and distributional patterns implies a shared biogeographical history.

3. Vicariance biogeography fully developed by Platnick & Nelson (1978)

4. Event based estimations of biogeographic history

IV. Generally used methods of Historical (Vicariance) Biogeography

A. Similar systems like parasites and their hosts can use the same or similar methods.

<u>Host - Associate</u>
Organism - genes
Host organism - parasite organism
Geographic area - organism

VII. Comparative Biogeography (sensu Parenti & Ebach 2009)

1. Focus is on homology of natural areas not on speciation or other diversity generation processes.
2. Defined as “the comparative study of biotic areas and their relationships through time”
3. Uses “paralogy-free subtree analysis”

VIII. Event based optimality methods for estimation of biogeographic history (Ronquist & Sanmartin 2011 and Crisp et al., 2011)

1. Biogeographic history is another step of abstraction from phylogeny
2. Event-based methods is rapidly expanding due to advances in ML and Bayesian methods, parametric statistics, DNA data and fossil data.
3. Calibrated phylogenies
4. DIVA, DEC, HVM…

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