Reading DNA to infer ancient flight

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What we see today is the outcome of what happened in the past.....

........EVOLUTION

........SPECIATION
PHYLOGENY of LIFE
Phylogenetics - 1960s

Historical biogeography ~ past distributions
Allopatric speciation

Sympatric speciation
Allopatric speciation

Speciation occurs in geographic isolation (*no gene flow*)

- Rivers & Oceans
- Mountain ranges
- Deserts
- Land (in case of aquatic organisms)
Figure 1

1. No barrier; one species.

2. Barrier allows differences to develop in two populations.

3. Differences so great that two species are evident.

4. When barrier is removed, species do not interbreed.

Figure source: James F. Thompson
Allopatric speciation by *Vicariance* and *Dispersal*

Colonization *before* v/s *after*
Global-scale patterns of allopatric speciation

pre-1960’s era of historical biogeography
- belief in a stable earth
- concept of phylogeny unknown

Identification of centres-of-origin

Kodandaramaiah 2009. Evolutionary Biology
Ratite (flightless) birds

Source: www.geo.arizona.edu

Photo: GD Rowley

Photo: David Bygott

Photo: GD Rowley
The Origin of Continents and Oceans - Alfred Wegener 1915.

Accepted in the 1960s
540 Ma
Nemakitian-Daldynian (Early Cambrian)
450 Ma
Caradocian (Late Ordovician)

PLATES UTIG
August 2002
440 Ma
Early Llandoveryan (Early Silurian)

PLATES 
August 2002
430 Ma
Late Llandoveryan (Early Silurian)

August 2002
400 Ma
Late Praghian/Early Emsian (Early Devonian)
380 Ma
Late Eifelian/Early Givetian (Middle Devonian)
370 Ma
Late Givetian/Early Frasnian (Late Devonian)
360 Ma
Famennian (Late Devonian)

PLATESUTIG
August 2002
350 Ma
Touraisian (Mississippian)

PLATES & TIG
August 2002
330 Ma
Late Visean (Mississippian)
300 Ma
Kasimovian (Pennsylvanian)
280 Ma
Early Sakmarian (Early Permian)

PLATES
August 2002
260 Ma
Late Artinskian/Early Kungurian (Early Permian)

PLATES® UTIG
August 2002
230 Ma
Ladinian (Middle Triassic)
210 Ma
Late Norian (Late Triassic)

PLATES/UTIG
August 2002
200 Ma
Sinemurian (Early Jurassic)

PLATES
August 2002
150 Ma
Volgian (Late Jurassic)

Gondwana

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August 2002
Gondwana

140 Ma
Ryazanian (Early Cretaceous)

Gondwana

PLATES UTIG
August 2002
130 Ma
Hauterivian (Early Cretaceous)

Gondwana

PLATES / UTIG
August 2002
110 Ma
Early Albian (Early Cretaceous)

Gondwana

PLATES©UTIG
August 2002
70 Ma
Maastrichtian (Late Cretaceous)

PLATES\UTIG
August 2002
Present day
1960’s Acceptance of continental drift
Phylogenetics

(a) Gondwana was the original home of ratites.

(b) Gondwana began to break up into separate continents.

(c) Ratites speciated as the continents moved apart.

Figure 25-6 Biological Science, 2/e © 2005 Pearson Prentice Hall, Inc.
Vicariance biogeography

Vicariance – null explanation for allopatric distributions

- much more likely

Dispersal – invoked only after rejection of vicariance

- less likely

Gareth Nelson on dispersalism:

’the science of the improbable, the rare, the mysterious and the miraculous’

Kodandaramaiah. *Evolutionary Biology*
Molecular Phylogenetics
Molecular dating

Time since divergence

Percent sequence divergence

X

Y
Molecular dating

Outgroup
Species 1
Species 2
Species 3
Species 4

Fossil for Species 4
~1 MY

Species 3
Species 4

2% Sequence Divergence

Outgroup
Species 1
Species 2
Species 3
Species 4

5MY
2MY
1MY
Biogeography of the genus *Junonia*:
Testing hypotheses of vicariance and dispersal

Kodandaramaiah & Wahlberg 2007 *Journal of Evolutionary Biology*
simple VICARIANCE scenario
simple DISPERSAL scenario
Predictions

simple VICARIANCE scenario:

species within different regions descend from a single ancestor

simple DISPERSAL scenario:

Asian species nested within African
Australian species nested within Asian
New World species nested within African
Molecular phylogeny

3 genes: 3000 bp

1 mitochondrial - COI
2 nuclear - EF1-alpha & wingless
Predictions:

*simple VICARIANCE scenario:*

species within different regions descend from a single ancestor.

*simple DISPERSAL scenario?*

Kodandaramaiah & Wahlberg *Journal of Evolutionary Biology*
Molecular Dating estimate

Collision of Africa+Arabia with Asia ca. 19 mya

ca. 20 mya

Kodandaramaiah & Wahlberg *Journal of Evolutionary Biology*
Subtribe Mycalesina (bushbrowns)

- Old World tropics. > 300 species.
- Madagascar, Africa, SE Asia, New Guinea + Solomons
Heteropsis

20 mya

Madagascar

W Ghats

W Ghats

Madagascar

Madagascar

Madagascar

Madagascar

Photos: Balakrishnan Valappil
Lineage Through Time (LTT) Plots

Photo: Giles San Martin
Africa

Lineages Through Time Plot

- Grassland (savanna)
- Forest

Log Number of Lineages

Time
Family Nymphalidae – 540 genera; 6000 spp
(genus > genera)

Wahlberg, Leneveu, Kodandramaiah et al *Proceedings B*
400 genera
8 genes
>6000bp
K-T crisis

Asteroid/meteorite impact?
Chicxulub crater (Mexico)

Deccan Traps volcanism?
Southern India
Neotropics and/or Oriental

Oriental

Neotropics and/or Oriental

Oriental and/or Neotropics

Neotropics and/or Oriental

Oriental and/or Neotropics

Neotropics and/or Oriental

Oriental and/or Neotropics

Neotropics, Oriental, or widespread including Afrotropics

Oriental (and Neotropics?)

Neotropics, Oriental, Australia

Oriental and/or Afrotropics

Oriental

Neotropics and/or Oriental

Neotropics and/or Oriental

Neotropics and/or Oriental

Neotropics, Oriental, Afrotropics

Neotropics and/or Oriental

Neotropics, Oriental, or widespread including Afrotropics

Oriental (and Neotropics?)
When and where major diversification events happened

Nymphalidae originated before K/T boundary, diversified after

Asia and South America – centres of diversification through
Speciation by Dispersal

pre 1960’s: dominant view

1960’s: ’the science of the improbable, the rare, the mysterious and the miraculous’

Now?: dispersal is fundamental to allopatric speciation

Kodandaramaiah. *Evolutionary Biology*
Kodandaramaiah. *Journal of Biogeography*
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Collaborators