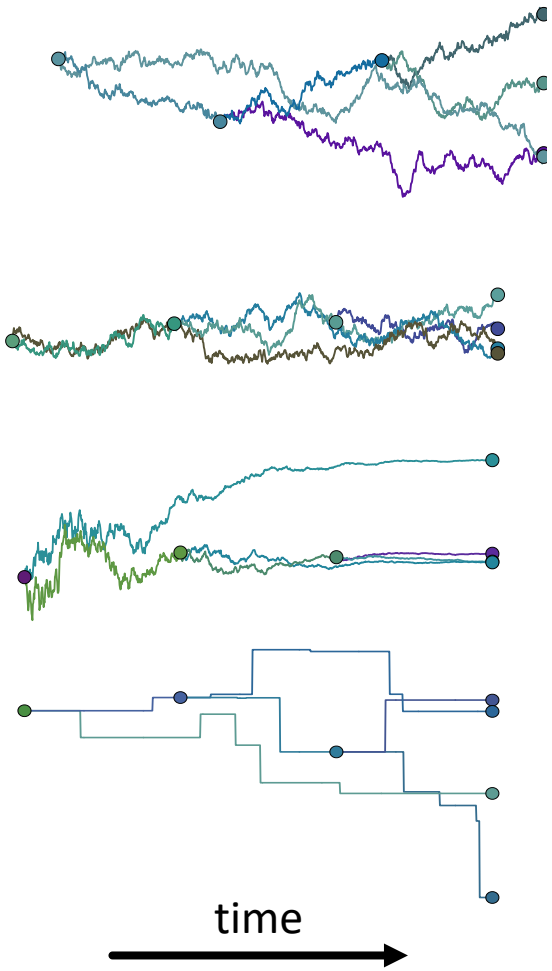
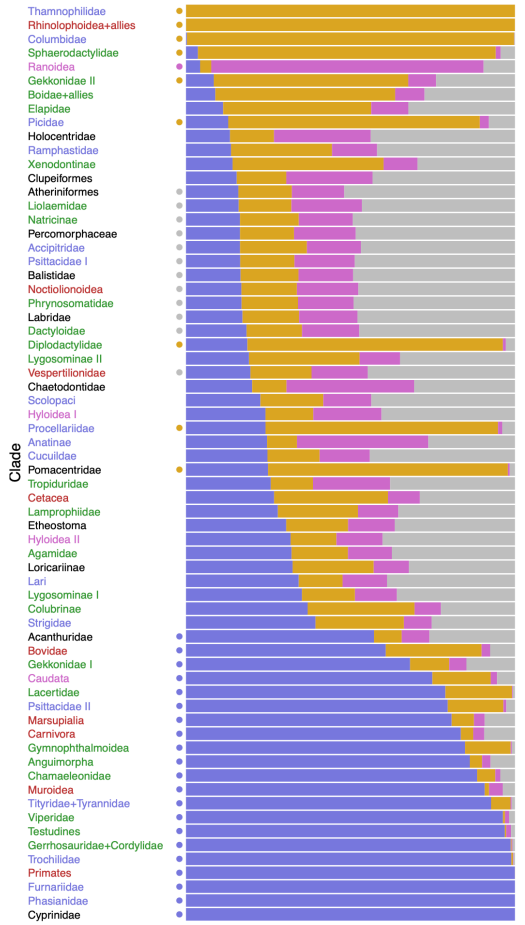
Wandering change
(Brownian motion)

Stationary change
(Ornstein-Uhlenbeck)

Explosive change
(Early Burst)

Pulsed change
(Lévy)

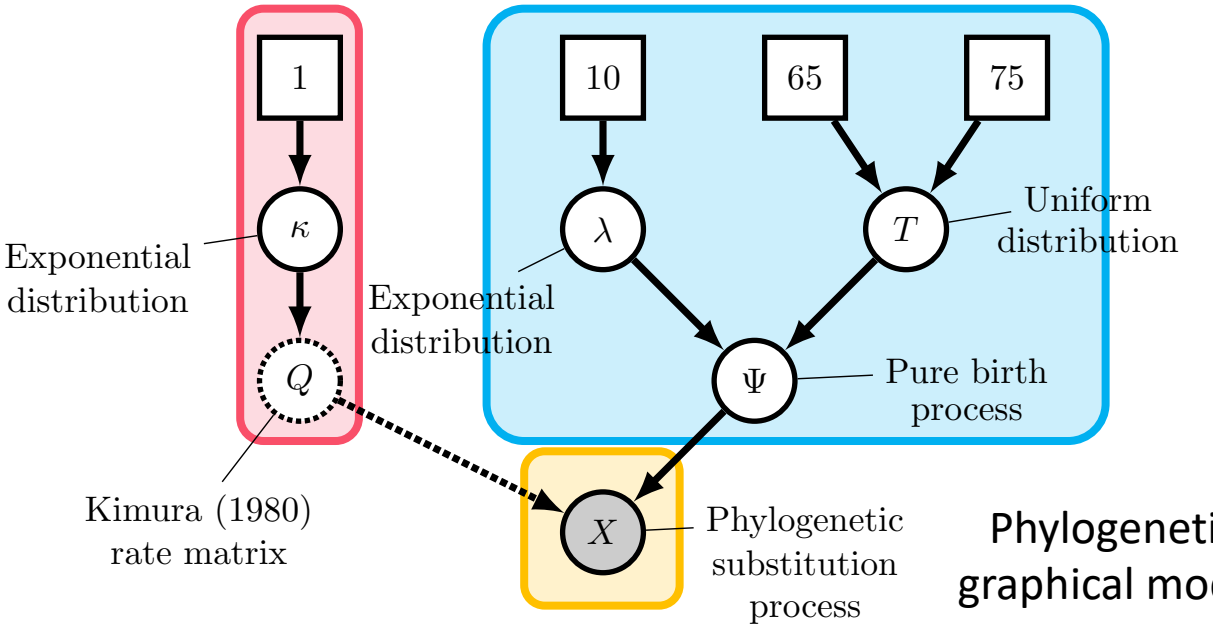




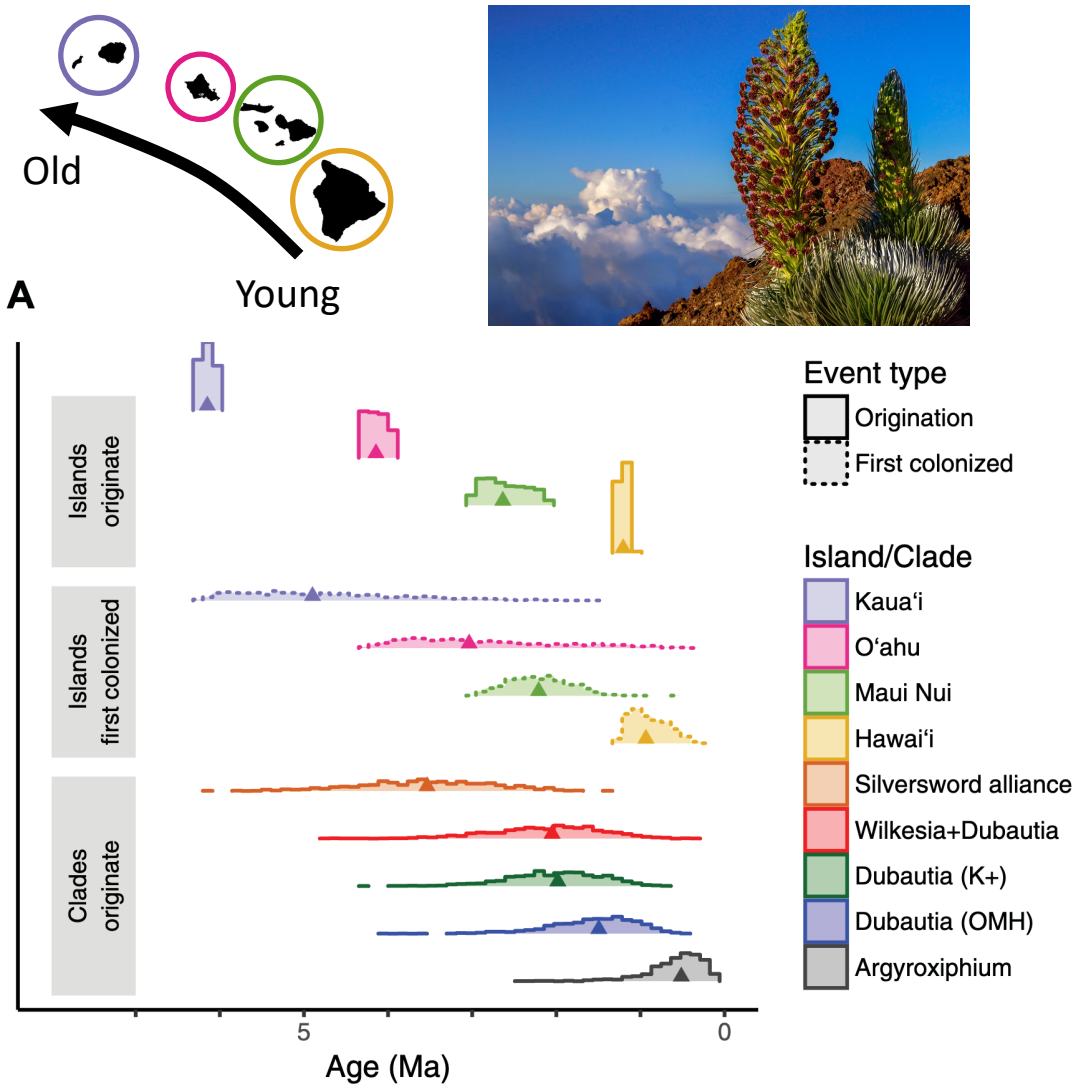
model support (AICc weights)

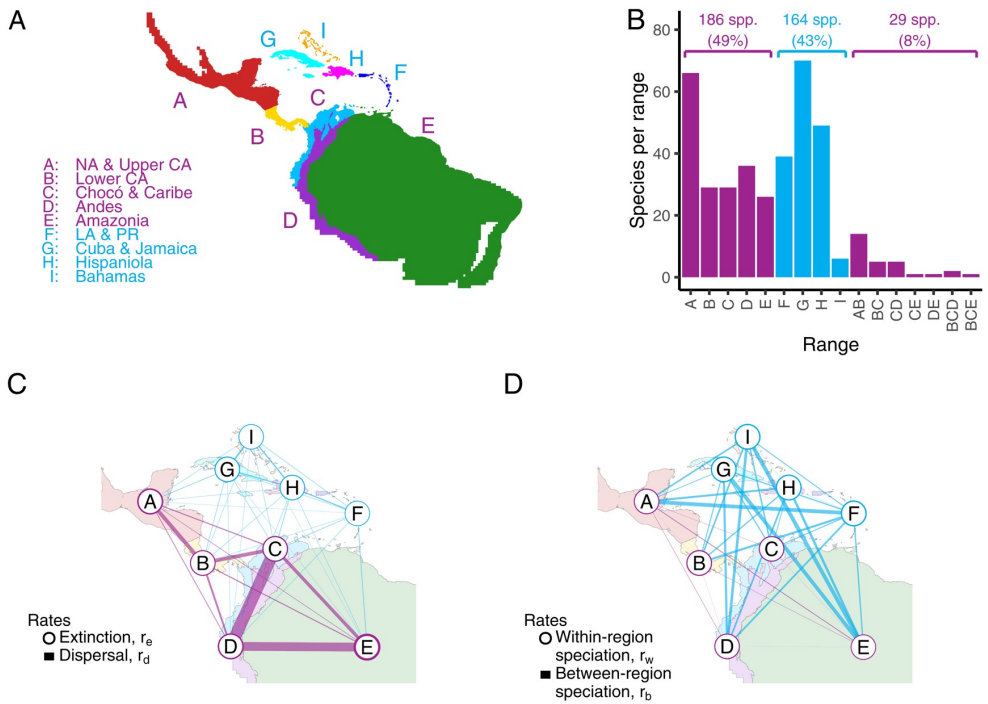
```
# pure birth prior and hyperpriors
birth ~ dnExponential(10)
tree_age ~ dnUnform(65, 75)
tree ~ dnBDP(birth, tree_age, taxa)
# rate matrix
kappa ~ dnExponential(1)
Q := fnK80(kappa)
# phylogenetic substitution process
seq ~ dnPhyloCTMC(Q, tree, “DNA”)
seq.clamp(data)
```

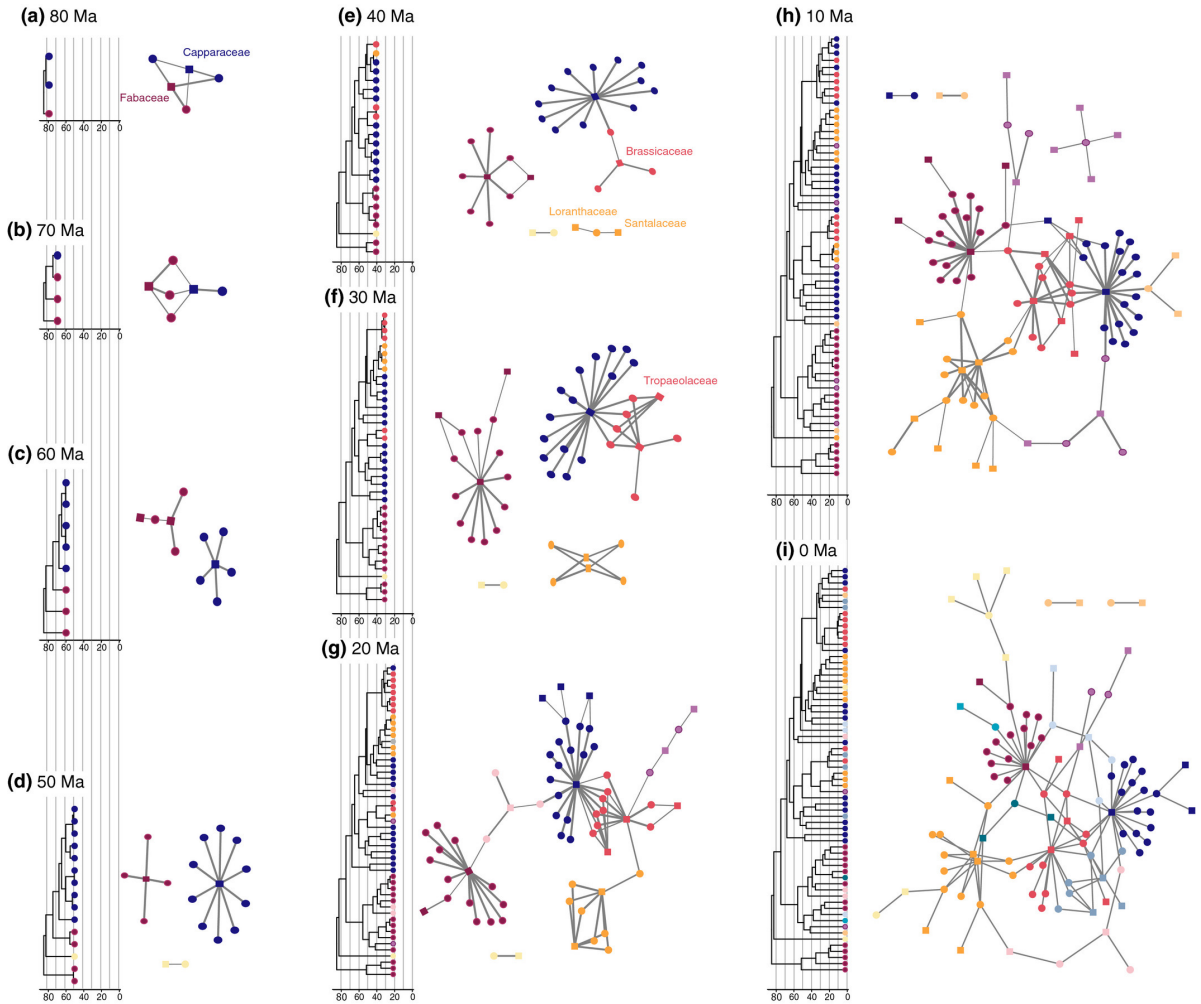
RevBayes code

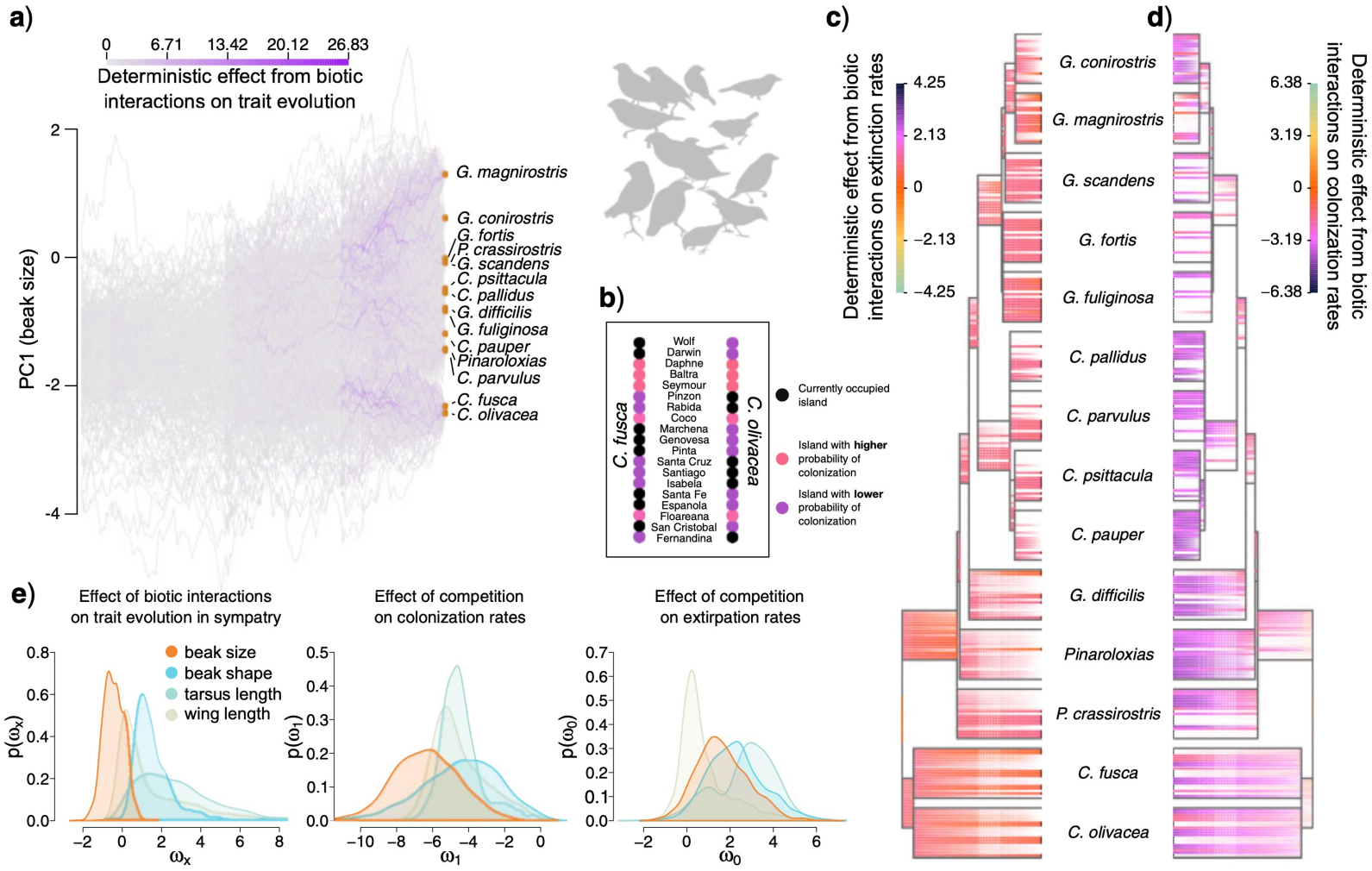


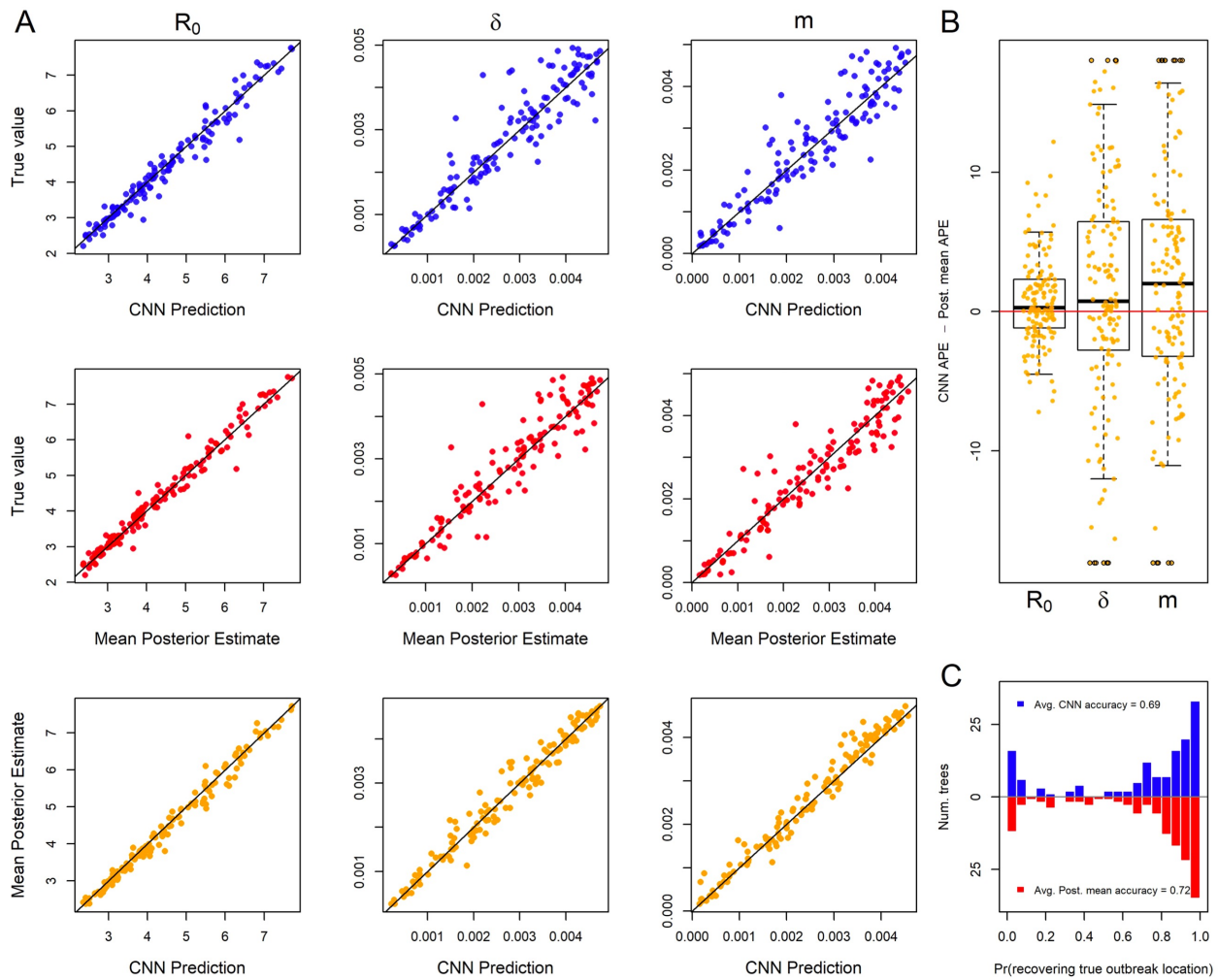
Phylogenetic graphical model

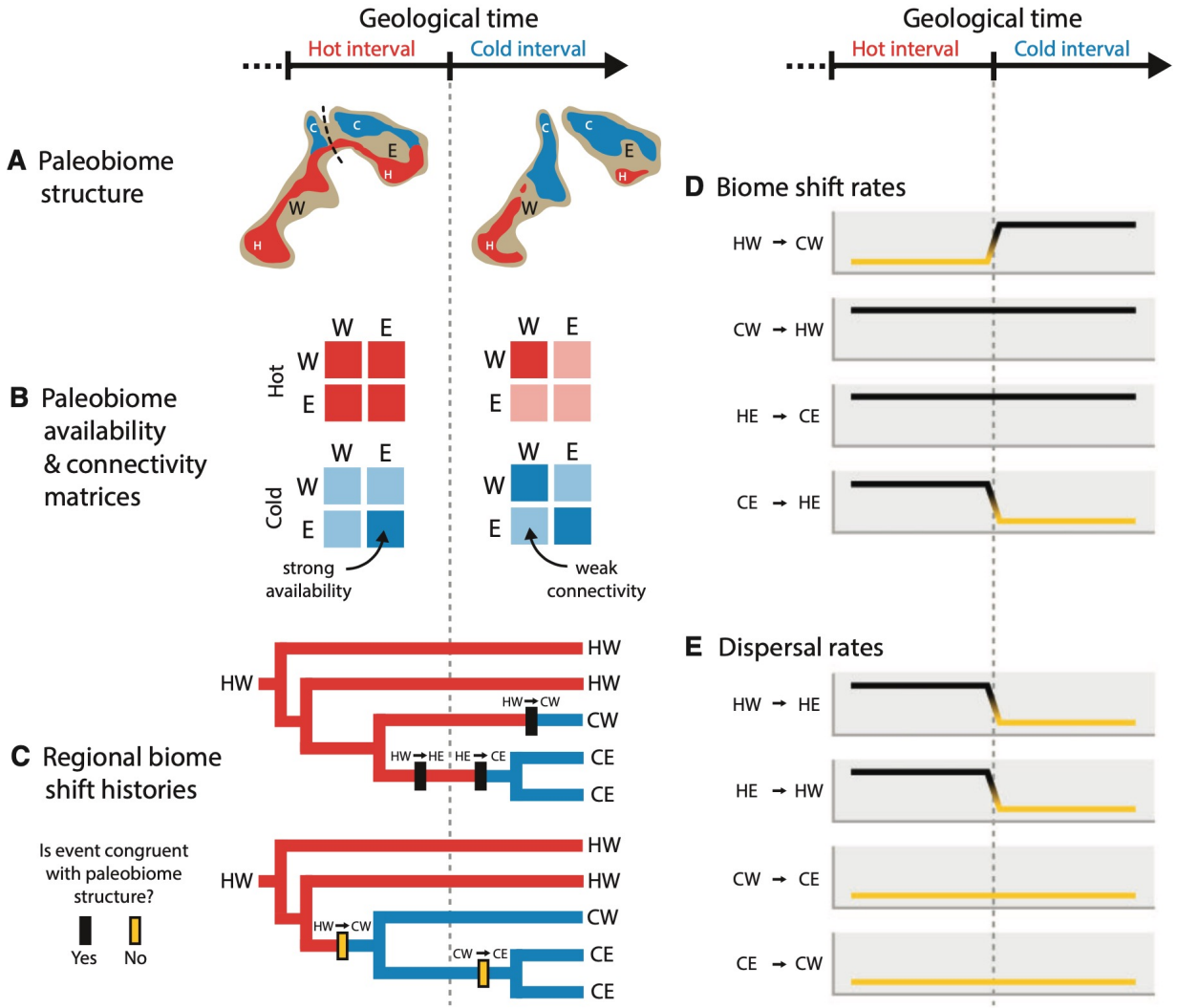

Old
Young
A
Islands originate
Islands first colonized
Clades originate
5
0
Age (Ma)
Event type
Origination
First colonized
Island/Clade
Kaua‘i
O‘ahu
Maui Nui
Hawai‘i
Silversword alliance
Wilkesia+Dubautia
Dubautia (K+)
Dubautia (OMH)
Argyroxiphium


A
A: NA & Upper CA
B: Lower CA
C: Chocó & Caribe
D: Andes
E: Amazonia
F: LA & PR
G: Cuba & Jamaica
H: Hispaniola
I: Bahamas
B
186 spp. (49%)
164 spp. (43%)
29 spp. (8%)
Species per range
Range
C
Rates
Extinction, r_e
Dispersal, r_d
D
Rates
Within-region speciation, r_w
Between-region speciation, r_b


(a) 80 Ma
Capparaceae
Fabaceae
80 60 40 20 0
(b) 70 Ma
80 60 40 20 0
(c) 60 Ma
80 60 40 20 0
(d) 50 Ma
80 60 40 20 0
(e) 40 Ma
Brassicaceae
Loranthaceae
Santalaceae
80 60 40 20 0
(f) 30 Ma
Tropaeolaceae
80 60 40 20 0
(g) 20 Ma
80 60 40 20 0
(h) 10 Ma
80 60 40 20 0
(i) 0 Ma
80 60 40 20 0


a)
0
6.71
13.42
20.12
26.83
Deterministic effect from biotic interactions on trait evolution
PC1 (beak size)
2
0
-2
-4
G. magnirostris
G. conirostris
G. fortis
P. crassirostris
G. scandens
C. psittacula
C. pallidus
G. difficilis
G. fuliginosa
C. pauper
Pinaroloxias
C. parvulus
C. fusca
C. olivacea
b)
C. fusca
C. olivacea
Wolf
Darwin
Daphne
Baltra
Seymour
Pinzon
Rabida
Coco
Marchena
Genovesa
Pinta
Santa Cruz
Santiago
Isabela
Santa Fe
Espanola
Floareana
San Cristobal
Fernandina
Currently occupied island
Island with higher probability of colonization
Island with lower probability of colonization
c)
Deterministic effect from biotic interactions on extinction rates
4.25
2.13
0
−2.13
−4.25
d)
Deterministic effect from biotic interactions on colonization rates
6.38
3.19
0
−3.19
−6.38
G. conirostris
G. magnirostris
G. scandens
G. fortis
G. fuliginosa
C. pallidus
C. parvulus
C. psittacula
C. pauper
G. difficilis
Pinaroloxias
P. crassirostris
C. fusca
C. olivacea
e)
Effect of biotic interactions on trait evolution in sympatry
beak size
beak shape
tarsus length
wing length
p(ωx)
ωx
Effect of competition on colonization rates
p(ω1)
ω1
Effect of competition on extirpation rates
p(ω0)
ω0


A
R_0
δ
m
True value
Mean Posterior Estimate
CNN Prediction
B
CNN APE − Post. mean APE
R_0
δ
m
C
Num. trees
Avg. CNN accuracy = 0.69
Avg. Post. mean accuracy = 0.72
Pr(recovering true outbreak location)


Geological time
Hot interval
Cold interval
A Paleobiome structure
C
E
H
W
B Paleobiome availability & connectivity matrices
W E
Hot
Cold
strong availability
weak connectivity
C Regional biome shift histories
HW
CW
CE
HW→CW
HW→HE
HE→CE
CW→CE
Is event congruent with paleobiome structure?
Yes
No
D Biome shift rates
HW → CW
CW → HW
HE → CE
CE → HE
E Dispersal rates
HW → HE
HE → HW
CW → CE
CE → CW