A New Global Palaeobiogeographical Model for the late Mesozoic and early Tertiary

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APPENDIX 4

Dispersal-Vicariance Analyses

In order to reconstruct the biogeographical history of three main clades purportedly dispersed from Africa to South America by trans-oceanic rafting during the Paleogene dispersal-vicariance analyses were performed in S-DIVA 1.5c (Yu et al. 2010). The dispersal-vicariance analysis reconstructs the ancestral geographic areas of each node of the phylogenetic tree by optimizing a three-dimensional cost matrix, in which extinctions and dispersals "cost" more than vicariance (Ronquist 1997; Lamm and Redelings 2009). The S-DIVA recovers the statistical support for ancestral range reconstructions (Yu et al. 2009). The frequencies of an ancestral range at a node in ancestral reconstructions are averaged over all trees and each alternative ancestral range at a node is weighted by the frequency of the node occurring or by some other measure support for the node (Yu et al. 2009).

Results of S-DIVA

Amphisbaenia.—The ancestral biogeographical reconstruction recovered all geographic areas at the base of the tree (ABCDE: with a frequency of 37%; see Fig. S14 for abbreviations), resembling that recovered for all non-rhineurid amphisbaenians but excluding North America in this case (BCDE: 37%). The node including Bipedidae, Blanidae, and Cadeidae reconstructed South and Central America (B: 47%) as the most likely ancestral area. Within this group, South and Central America (B: 100%) were recovered as the ancestral area for Bipedidae and South and Central Amerca-Africa-Europe

(BCD: 53%) for the node including Blanidae and Cadeidae. Accordingly, we can infer a dispersal event from South and Central America towards Africa and Europe based on the ancestral area of the Bipedidae-Blanidae-Cadeidae group and distribution of Blaneidae (Africa and Europe) (Fig. S14).

In the node including Trogonophidae and Amphisbaenidae, three equally probable ancestral areas were reconstructed: Africa (C: 32%), Africa-Europe (CE: 32%), and South and Central America-Africa-Europe (BCE: 32%). The reconstructed ancestral area for the Amphisbaenidae was South and Central America-Africa (100%) (Fig. S14). The entire genus *Amphisbaena* is of a South and Central American distribution. Accordingly, although a dispersion from Africa towards South America seems to be likely for basal amphisbaenids based on the reconstructed ancestral areas of the Trogonophidae-Amphisbaenidae node, we can not find conclusive evidence in our analysis for the presence of this event.

Histricognathi.—The reconstructed ancestral area for the sample of histricognathi rodents considered here was Asia (A: 100%). An Asia-Africa (AB: 100%) ancestral area was recovered in some of the lesser inclusive nodes among non-caviomorph histricognathi. The clade including the genus *Phiomys*, *Hystrix*, and histricognathi caviomorphs was recovered in the analysis as presenting an African ancestral area (B: 100%). The node including caviomorph rodents and the genus *Hystrix* was reconstructed as of an African-South American ancestral area (BD: 100%) and at the base of Caviomorpha the reconstructed ancestral area was South America (D: 100%). Accordingly, a dispersal event from Africa towards South America is evident at the base of the caviomorph lineage (Fig. S15).

Within Caviomorpha, most of the successive lesser inclusive clades present a South American ancestral area (A: 100%), but a South America-Africa area (BD: 100%) is reconstructed for the node including the African genus *Gaudeamus* and the clade including the South American *Incamys*, *Sallamys*, and *Platypittamys*. An African ancestral area was unambiguously depicted for the genus

Gaudeamus (Coster et al. 2010). In consequence, a second trans-Atlantic dispersal event from South America towards Africa is found for the genus *Gaudeamus* (Fig. S15).

Malpighiaceae.—A South and Central America-Africa-Asia ancestral area was reconstructed for the two more inclusive clades of the malpighiacean sample analyzed here (ACD: 100%). At the node including *Mcvaughia* and *Barnebya*, the reconstructed ancestral area was South and Central America (A: 100%), and this pattern is retained along most of the lineage. However, at the node including the South American genus *Heladena* and the African and Malagasy genus *Tristelateia*, the reconstructed ancestral area was South and Central America-Africa (AC: 100%), and those for the genus *Tristelateia* was Africa (C: 100%). Accordingly, a dispersal event from South America towards Africa and Madagascar is inferred for the genus *Tristelateia* based on the analysis performed here (Fig. S16).

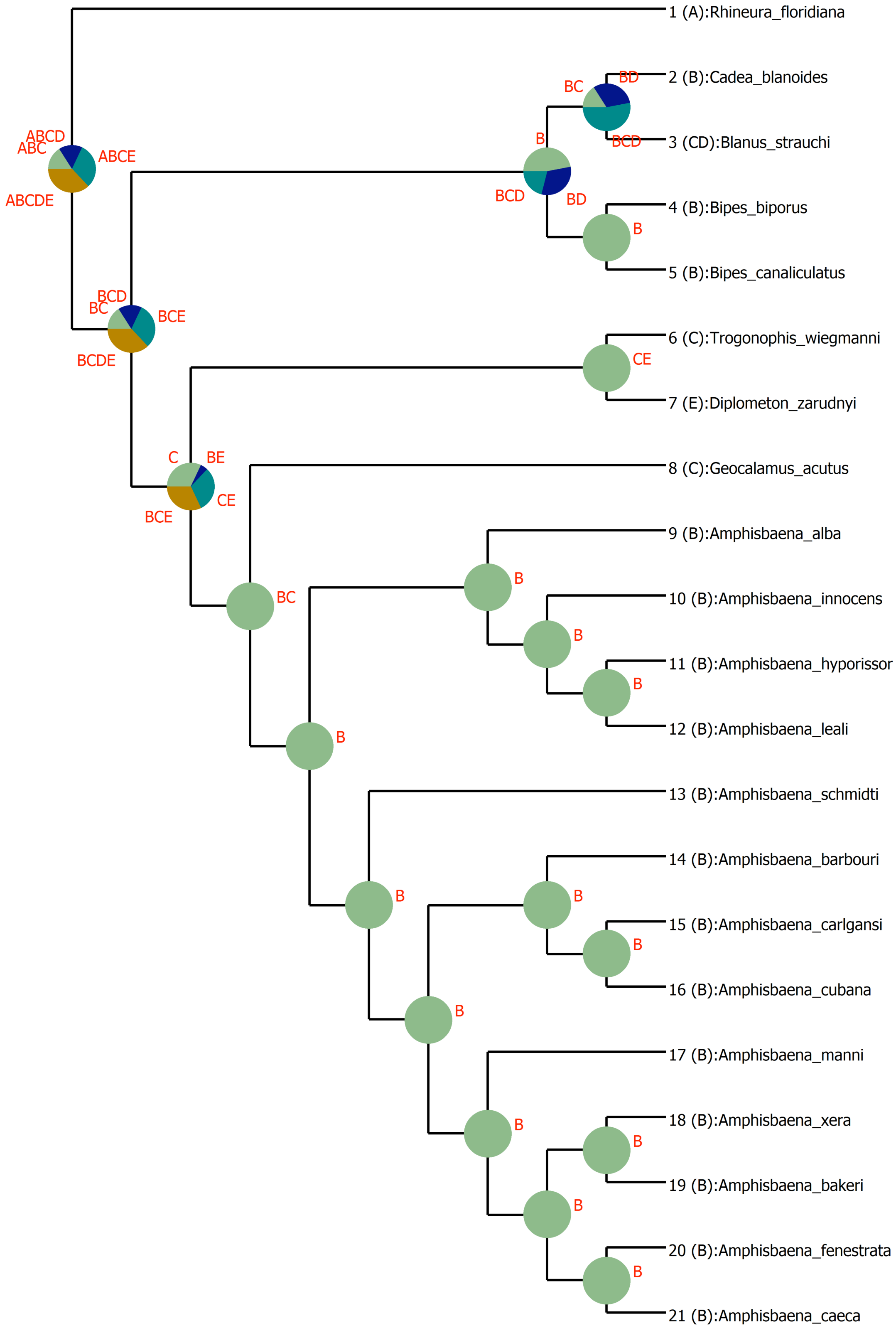

FIGURE S14. Results of the dispersal-vicariance analysis of amphisbaenian lepidosaurs. Abbreviations: A, North America; B, South and Central America; C, Africa; D, Europe; E, Asia.

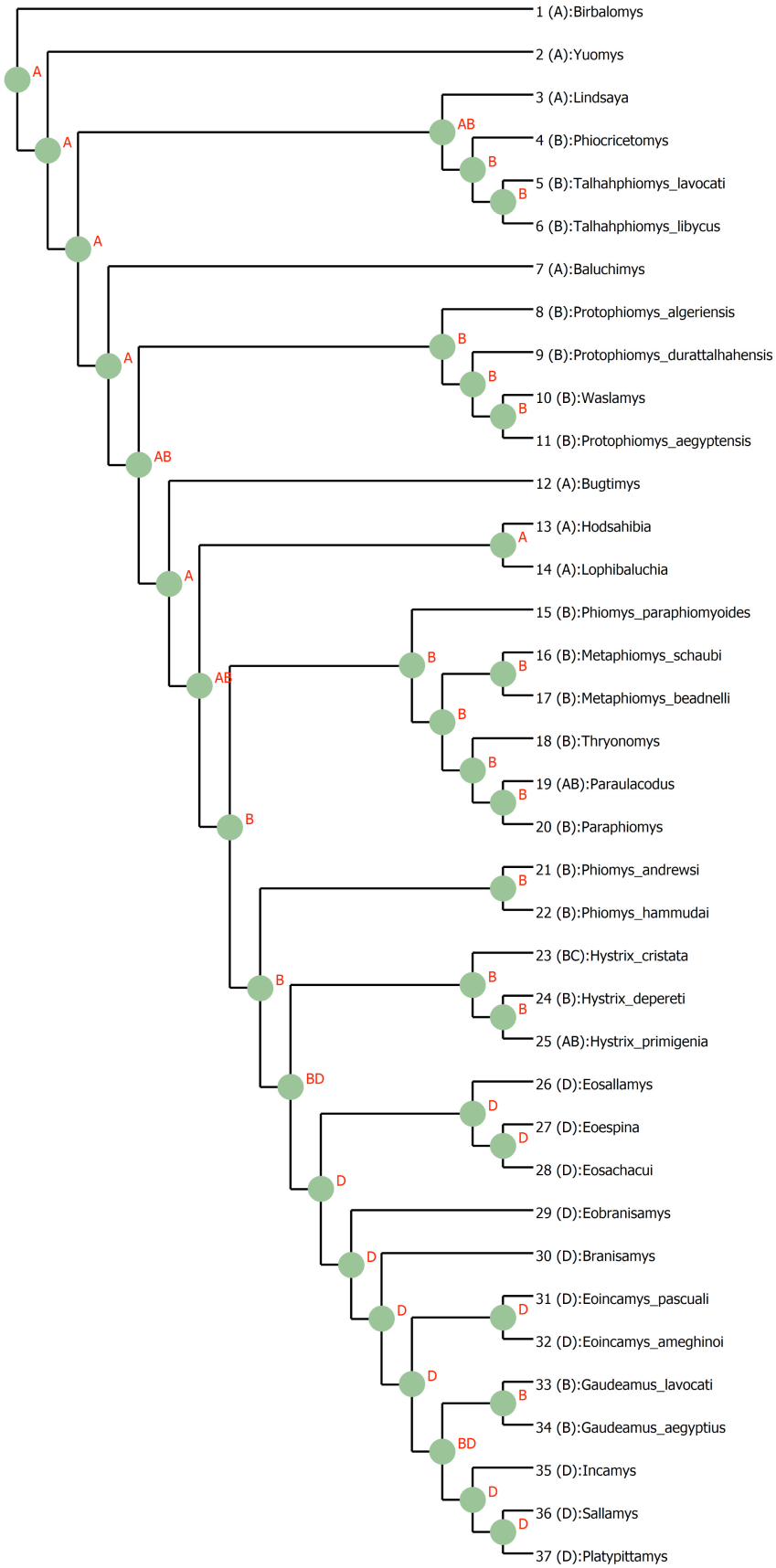

FIGURE S15. Results of the dispersal-vicariance analysis of histricognath rodents. Abbreviations: A, Asia; B, Africa; C, Europe; D, South America.

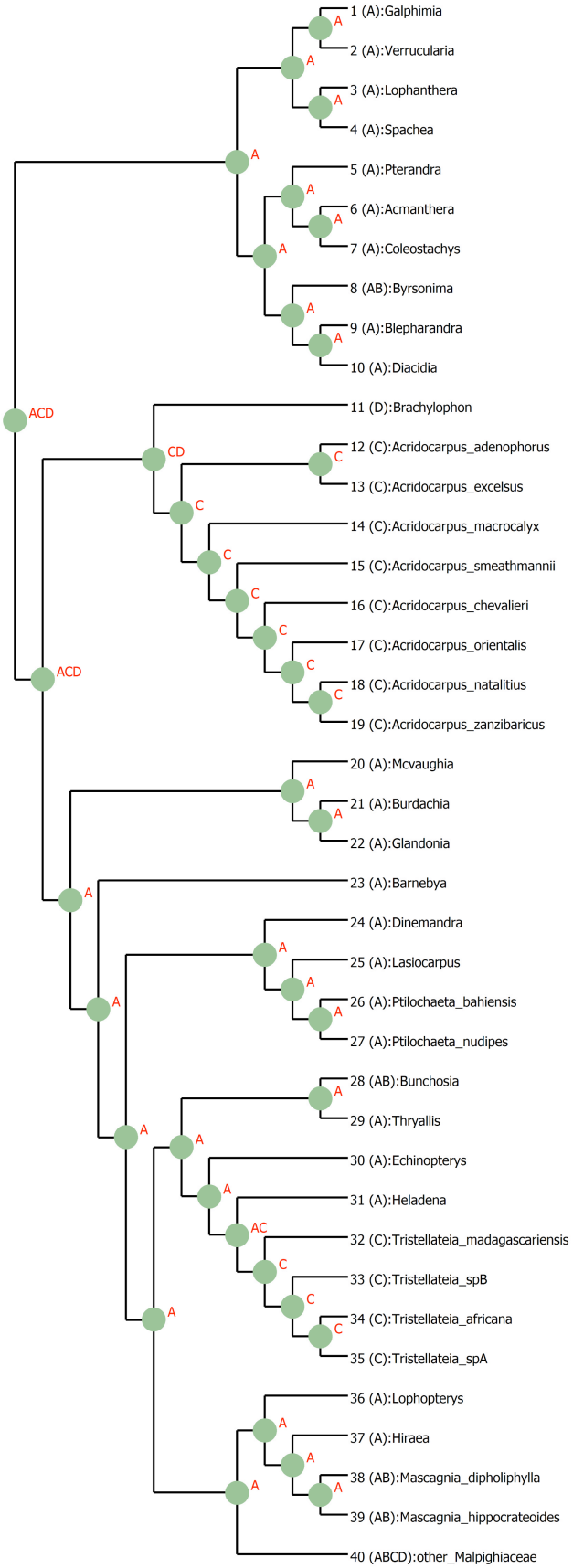

FIGURE S16. Results of the dispersal-vicariance analysis of malpighiacean angiosperms. Abbreviations: A, South and Central America; B, North America; C, Africa; D, Asia.

Geographic Distribution of the Taxa used in the Dispersal-Vicariance Analyses

Abbreviations: AF, Africa; AS, Asia; EU, Europe; SA, South America.

Amphisbaenia.—All the amphisbaenian taxa employed here are extant and the geographical distribution is taken from Vidal et al. (2008).

Amphisbaena alba: North and Central South America

Amphisbaena bakeri: Central America

Amphisbaena barbouri: Central America

Amphisbaena caeca: Central America

Amphisbaena carlgansi: Central America

Amphisbaena cubana: Central America

Amphisbaena fenestrata: Central America

Amphisbaena hyporissor: Central America

Amphisbaena innocens: Central America

Amphisbaena leali: Central America

Amphisbaena manni: Central America

Amphisbaena schmidti: Central America

Amphisbaena xera: Central America

Bipes biporus: Mexico

Bipes canaliculatus: Mexico

Blanus strauchi: Africa, Europe

Cadea blanoides: Central America

Diplometon zarudnyi: Asia

Geocalamus acutus: Africa

Rhineura floridiana: North America

Trogonophis wiegmanni: Africa

Histricognathi.—The geographical data of the following rodent taxa was taken from Coster et al. (2010).

Baluchimys ganeshapher: AS (Late Eocene-Early Oligocene)

Birbalomys woodi: AS (Middle Eocene)

Branisamys luribayensis: SA (Late Oligocene)

Bugtimys zafarullahi: AS (Early Oligocene)

Eobranisamys romeropittmanae: SA (Late Eocene)

Eoespina woodi: SA (Late Eocene)

Eoincamys ameghinoi: SA (Late Eocene)

Eoincamys pascuali: SA (Late Eocene)

Eosachacui lavocati: SA (Late Eocene)

Eosallamys paulacoutoi: SA (Late Eocene)

Gaudeamus aegyptius: AF (Early Oligocene)

Gaudeamus lavocati: AF (Early Oligocene)

Hodsahibia azrae: AS (Early Oligocene)

Hystrix cristata: AF EU (Pleistocene-Recent)

Hystrix depereti: AF (Late Miocene-Pliocene)

Hystrix primigenia : AF AS (Late Miocene-Pliocene)

Incamys bolivianus: SA (Late Oligocene)

Lindsaya derabugtiensis: AS (Early Oligocene)

Lophibaluchia pilbeami: AS (Early Oligocene)

Metaphiomys beadnelli: AF (Early Oligocene)

Metaphiomys schaubi: AF (Early Oligocene)

Paraphiomys pigotti: AF (Late Oligocene-Lower Miocene)

Paraulacodus: AS AF (Early Miocene)

Phiocricetomys minutus: AF (Early Oligocene)

Phiomys andrewsi: AF (Oligocene)

Phiomys hammudai: AF (Middle Eocene)

Phiomys paraphiomyoides: AF (Early Oligocene)

Platypittamys: SA (Late Oligocene)

Protophiomys aegyptensis: AF (Late Eocene)

Protophiomys algeriensis: AF (Middle Eocene)

Protophiomys durattalhahensis: AF (Middle Eocene)

Sallamys pascuali: SA (Late Oligocene)

Talhahphiomys lavocati: AF (Middle Eocene-Early Oligocene)

Talhahphiomys libycus: AF (Middle Eocene)

Thryonomys swinderianus: AF (Pleistocene)

Waslamys attiai: AF (Late Eocene)

Yuomys: AS (Late Eocene)

Malpighiaceae.—All the malpighiacean taxa employed here are extant. The data of the geographic distribution of the Malpighiaceae taxa employed here was mainly collected from Davis et al. (2002) and Anderson (2007).

Acmanthera: Brazil

Acridocarpus spp: Continental tropical Africa and Madagascar

Barnebya: Brazil

Blepharandra: Guyana, Venezuela and Amazonia

Brachylophon: Malasian Peninsula and Sumatra

Bunchosia:America

Burdachia: South America

Byrsonima: Mexico, Florida, Caribbean, and Brazil

Coleostachys: South America

Diacidia: South America

Dinemandra: South America

Echinopterys: Mexico

Galphimia: from Argentina to Mexico

Glandonia: Colombia, Venezuela, and Brazil

Heladena: Brazil, Paraguay, and Argentina

Hiraea: Mexico, Paraguay, Argentina, and Brazil

Lasiocarpus: Central America

Lophanthera: Costa Rica and Amazonia

Lophopterys: South America

Mascagnia spp: South America

Mcvaughia: Brazil

Pterandra: Colombia, Brazil, Venezuela, and Panama

Ptilochaeta spp: South America

Spachea: Cuba, Central America and north of South America

Thryallis: Brazil, Paraguay, and Bolivia

Tristellateia spp: Africa and Madagascar

Verrucularia: Amazonia