Science Advances

AAAS

advances.sciencemag.org/cgi/content/full/2/8/e1600883/DC1

Supplementary Materials for

Formation of the Isthmus of Panama

Aaron O'Dea, Harilaos A. Lessios, Anthony G. Coates, Ron I. Eytan, Sergio A. Restrepo-Moreno, Alberto L. Cione, Laurel S. Collins, Alan de Queiroz, David W. Farris, Richard D. Norris, Robert F. Stallard, Michael O. Woodburne, Orangel Aguilera, Marie-Pierre Aubry, William A. Berggren, Ann F. Budd, Mario A. Cozzuol, Simon E. Coppard, Herman Duque-Caro, Seth Finnegan, Germán M. Gasparini, Ethan L. Grossman, Kenneth G. Johnson, Lloyd D. Keigwin, Nancy Knowlton, Egbert G. Leigh, Jill S. Leonard-Pingel, Peter B. Marko, Nicholas D. Pyenson, Paola G. Rachello-Dolmen, Esteban Soibelzon, Leopoldo Soibelzon, Jonathan A. Todd, Geerat J. Vermeij, Jeremy B. C. Jackson

Published 17 August 2016, *Sci. Adv.* **2**, e1600883 (2016)
DOI: 10.1126/sciadv.1600883

The PDF file includes:

- fig. S1. The Isthmus of Panama in Tropical America.
- fig. S2. The current day Isthmus of Panama submerged under 150 m of relative sea-level rise.
- fig. S3. Timing of successful terrestrial dispersals between the American continents as observed in the occurrence of fossil remains in the rock record of North and South America.
- Legend for video S1
- table S1. Estimates of rates of uplift for the Panama Arc relative to sea level, using changes in estimated median depths and median ages of sedimentary units from previous studies (*28*, *135–149*).
- table S2. Compilation of Late Paleocene–Late Eocene ages for the Colombian Andes plotted in Fig. 2.
- table S3. Median and 95% HPD intervals of the time at which members of clades spanning the Isthmus of Panama were separated from each other as estimated by BEAST (*151*) from phylogenies calibrated by fossils at one or more nodes.
- table S4. Kimura two-parameter distance between mitochondrial genes of sister clades on either side of the Isthmus of Panama.
- text S1. Estimation of date of splitting from molecular divergence.
- References (*150–227*)

Other Supplementary Material for this manuscript includes the following:

(available at advances.sciencemag.org/cgi/content/full/2/8/e1600883/DC1)

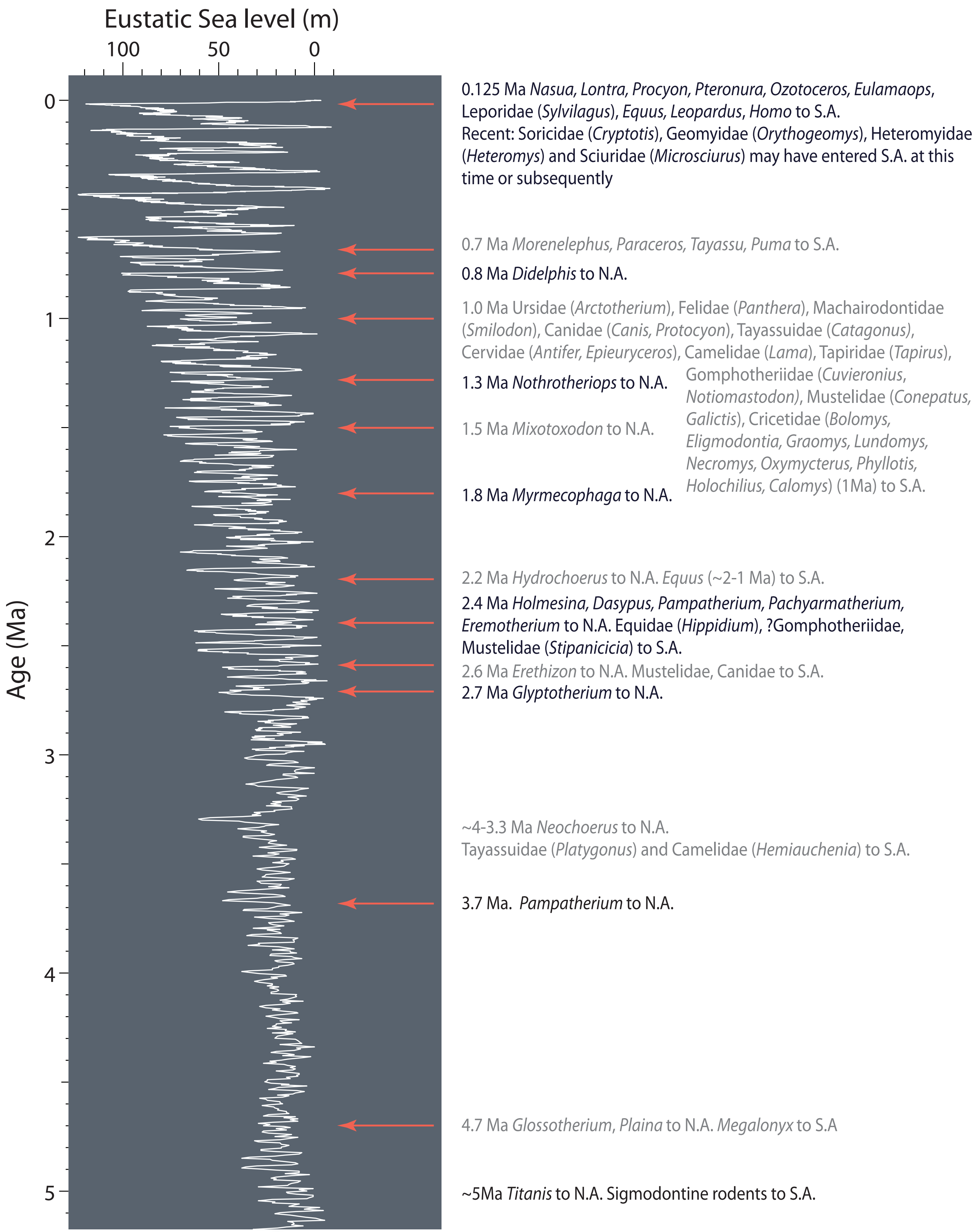
- video S1 (.mov format). Large rafts form on the Río Chagres, Gamboa, Republic of Panama, on the 8th of December, 2010.


NORTH AMERICA
CARIBBEAN SEA
Isthmus of Panama
PACIFIC OCEAN
SOUTH AMÉRICA

fig. S1. The Isthmus of Panama in Tropical America.


C A R I B B E A N S E A
Geologically-young
El Valle volcano
Atrato
'seaway'
Canal
'seaway'
P A C I F I C
O C E A N
200 km

fig. S2. The current day Isthmus of Panama submerged under 150 m of relative sea-level rise. Interoceanic connections form through hypothetical Canal and Atrato seaways. Such relative sea level rise is easily attained by reversing the moderate rates of tectonic uplift over the last few million years (Fig. 1). Dashed line follows the Darién-Acandi-Cuchillo-Debeiba structure. This is not a paleogeographic reconstruction as it does not compensate for tectonic movements, pre-emergence deposition, post-emergence erosion or volcanic activity. For example, the El Valle volcano is a geologically-young structure and its absence would have permitted greater interoceanic connection through the Canal 'seaway' (cf. *15*)



Eustatic Sea level (m)
100
50
0
Age (Ma)
0
1
2
3
4
5
0.125 Ma *Nasua, Lontra, Procyon, Pteronura, Ozotoceros, Eulamaops*, Leporidae (*Sylvilagus*), *Equus, Leopardus, Homo* to S.A.
Recent: Soricidae (*Cryptotis*), Geomyidae (*Orythogeomys*), Heteromyidae (*Heteromys*) and Sciuridae (*Microsciurus*) may have entered S.A. at this time or subsequently
0.7 Ma *Morenelephus, Paraceros, Tayassu, Puma* to S.A.
0.8 Ma *Didelphis* to N.A.
1.0 Ma Ursidae (*Arctotherium*), Felidae (*Panthera*), Machairodontidae (*Smilodon*), Canidae (*Canis, Protocyon*), Tayassuidae (*Catagonus*), Cervidae (*Antifer, Epieuryceros*), Camelidae (*Lama*), Tapiridae (*Tapirus*), Gomphotheriidae (*Cuvieronius, Notiomastodon*), Mustelidae (*Conepatus, Galictis*), Cricetidae (*Bolomys, Eligmodontia, Graomys, Lundomys, Necromys, Oxymycterus, Phyllotis, Holochilius, Calomys*) (1Ma) to S.A.
1.3 Ma *Nothrotheriops* to N.A.
1.5 Ma *Mixotoxodon* to N.A.
1.8 Ma *Myrmecophaga* to N.A.
2.2 Ma *Hydrochoerus* to N.A. *Equus* (~2-1 Ma) to S.A.
2.4 Ma *Holmesina, Dasypus, Pampatherium, Pachyarmatherium, Eremotherium* to N.A. Equidae (*Hippidium*), ?Gomphotheriidae, Mustelidae (*Stipanicicia*) to S.A.
2.6 Ma *Erethizon* to N.A. Mustelidae, Canidae to S.A.
2.7 Ma *Glyptotherium* to N.A.
~4-3.3 Ma *Neochoerus* to N.A.
Tayassuidae (*Platygonus*) and Camelidae (*Hemiauchenia*) to S.A.
3.7 Ma. *Pampatherium* to N.A.
4.7 Ma *Glossotherium, Plaina* to N.A. *Megalonyx* to S.A
~5Ma *Titanis* to N.A. Sigmodontine rodents to S.A.

fig. S3. Timing of successful terrestrial dispersals between the American continents as observed in the occurrence of fossil remains in the rock record of North and South America. Sea level data from (*131*).

video S1. Large rafts form on the Río Chagres, Gamboa, Republic of Panama, on the 8th of December, 2010. Footage from Collin McMillan.

table S1. Estimates of rates of uplift for the Panama Arc relative to sea level, using changes in estimated median depths and median ages of sedimentary units from studies (*28, 135-149*). See below for methodology.

Region	Unit 1	Unit 2	Median age Unit 1 (Ma)	Median age Unit 2 (Ma)	Median depth Unit 1 (m)	Median depth Unit 2 (m)	Median uplift rate relative to sea level (m Myr^{-1})
Bocas del Toro	Punta Alegre Fm., Valiente Peninsula	Valiente Fm., Llorona Hill, Valiente Peninsula	19.9	15.4	1500	800	155.6
Bocas del Toro	Valiente Fm., Toro Point, PPP site 3136	Valiente Fm., Toro Point, PPP sites 2730/31	15.4	12.6	400	400	0.0
Bocas del Toro	Isla Popa, Deer Island	Isla Popa, Punta Laurel	15	13.6	800	400	285.7
Bocas del Toro	Nancy Point Fm., Tobabe Point, Valiente Peninsula	Shark Hole Pt Fm, Bruno Bluff, Valiente Peninsula	6.1	3.7	400	175	93.8
Bocas del Toro	Cayo Agua Fm., NE Cayo Agua island	Cayo Agua Fm, NW Cayo Agua island	4.8	3.7	60	30	27.3
Bocas del Toro	Escudo de Veraguas Fm, NE part of Escudo de Veraguas island, PPP sites CJ88-30-11/12	Escudo de Veraguas Fm, NW part of Escudo de Veraguas island	3.7	1.9	75	75	0.0
Bocas del Toro	Escudo de Veraguas Fm, NW part of Escudo de Veraguas island	Modern	1.9	0	125	0	65.8
Bocas del Toro	Swan Cay island, off Isla Colon island, base of bluffs	Modern	1.3	0	100	1	76.2
Bocas del Toro	Bastimentos island, Fish Hole, Western Sequence	Modern	2.7	0	88	2	31.9
Limon	Uscari Fm, early Miocene *	Uscari Fm, middle Miocene #	17.7	15.8	800	400	210.5
Limon	Uscari Fm, e. middle Miocene, middle part of section of Cassell & Sen Gupta 1989	Uscari Fm, m. middle Miocene, upper part of section of Cassell & Sen Gupta 1989	15.8	13.9	400	150	131.6
Limon	Uscari Fm, m. middle Miocene, upper part of section of Cassell & Sen Gupta, 1989	Uscari Fm, Rio Sandbox and Carbon Dos sections	13.9	6.7	150	400	-34.7
Limon	Rio Banano Fm, Rio Banano, Quitaria section	Rio Banano Fm, Rio Banano, type section near Bomba	3.7	2.8	30	20	11.1
Limon	Rio Banano Fm, Rio Banano, type section near Bomba	Modern	2.8	0	20	5	5.4
Limon	Moin Fm, type section in unnamed creek in Cangrejos community	Modern	1.8	0	200	10	105.6
Limon	Moin Fm, E reef, Lomas del Mar Mbr	Modern	1.8	0	75	-50	69.4
Panama Canal	Gatun Fm, lower part	Gatun Fm, middle-upper part	11.6	9	25	25	0.0
Panama	Gatun Fm, upper part	Chagres Fm, Toro Point Mbr	9	7	25	350	-162.5

Canal							
Panama Canal	Gatun Fm, upper part	Chagres Fm, Rio Indio facies	9	7	25	65	-20.0
Panama Canal	Chagres Fm, Rio Indio facies	Chagres Fm, main facies	7	6.1	65	350	-316.7
Darien	Membrillo River, Clarita Fm	Membrillo River, Tapaliza Fm	15.6	12	1750	1000	208.3
Darien	Membrillo River, Tapaliza Fm	Membrillo River, Membrillo Fm	12	10.3	1000	1000	0.0
Darien	Membrillo River, Membrillo Fm	Membrillo River, Chucunaque Fm	10.3	6.4	1000	325	173.1
Darien	Tuquesa River, Clarita Fm	Tuquesa River,Tapaliza Fm	15	12.7	1000	1000	0.0
Darien	Tuquesa River, Tapaliza Fm	Tuquesa River,Tuira Fm, lower part	12.7	10.3	1000	45	397.9
Darien	Tuquesa River, Tuira Fm, upper part	Tuquesa River,Yaviza Fm	10.3	9	15	15	0.0
Darien	Tuquesa River, Yaviza Fm	Tuquesa River,Chucunaque Fm, lower part	9	7.1	15	15	0.0
Darien	Tuquesa River, Chucunaque Fm, base of section	Tuquesa River,Chucunaque Fm, upper part	7.1	6.4	15	150	-192.9
Darien	Tupisa River, Tuira Fm	Tupisa River, Yaviza Fm	9.6	9	15	15	0.0
Darien	Tupisa River, Yaviza Fm	Tupisa River, Chucunaque Fm	9	7.2	15	105	-50.0
Darien	Yaviza section, Tapaliza Fm, lower part	Yaviza section, Tapaliza Fm, upper part	12.8	11	1000	325	375.0
Darien	Yaviza section, Tapaliza Fm, upper part	Yaviza section, Tuira Fm, lower part	11	9.9	325	105	200.0
Darien	Yaviza section, Tuira Fm, upper part	Yaviza section, Yaviza Fm	9.9	9	15	325	-344.4
Darien	Tuira River, Tuira Fm	Tuira River, Yaviza Fm	9.9	9	325	105	244.4
Burica	Burica Fm	Armuelles Fm	2.6	0.4	1300	10	586.4

Methodology and notes

Rates of uplift relative to sea level were calculated using changes in the estimated depths of deposition of 38 sedimentary units in five sedimentary basins (Limon in Costa Rica, Bocas del Toro, Panama Canal basin, Darien and Burica in Panama).

Ages of deposition of sedimentary units were estimated using planktic foraminifera and calcareous nannoplankton while depth at deposition were estimated from assemblages of benthic foraminifera, both using references below. Rates of uplift relative to sea level for each sequence (defined as an older sedimentary unit to a younger sedimentary sequence) was calculated as:

(median depth of unit 1)-(medium depth of unit 2) / (median age of unit 1)-(median age of unit 2) where unit 1 is the older of the two sedimentary units.

When younger sedimentary units were not available we used the modern (i.e. age = 0 Ma, depth = 0 m). This approach is appropriate because all fossil stratigraphic units lay at or close to modern day sea level.

Mean rates of uplift relative to sea level were then calculated for each million year bin by including all the rates of uplift relative to sea level from sequences which crossed that time bin. Likewise, standard deviation was calculated for each mean in each time bin.
* = Lowest part of section of Cassel and Sen Gupta (*135*). # = Middle part of section from Cassel and Sen Gupta (*135*). § = Upper part of section from Cassel and Sen Gupta (*135*).

table S2. Compilation of Late Paleocene–Late Eocene ages for the Colombian Andes plotted in Fig. 2. Entries are organized in order of increased ages. Only data from the interval of interest (~59 to 33 Ma) relative to Montes et al.'s (2015) claims are reported. Radiometric ages compiled from various sources including references 1-3 bellow (see notes and references). Vast majority of radiometric ages in this critical interval fall outside of the Panama-Chocó Block litho-structural domain (see Fig. 2).

Lithologic Unit	Age (Ma)	Error ± Myr	Method	Lat.	Lon.	Ref.
Dacite	33.9	0.7	K/Ar wr	2.56	-76.69	(*132*)
Mandé Batholith (granodiorite)	34		K/Ar Bt	5.72	-76.35	(*132*)
Grupo Diabásico (dolerite)	34		K/Ar	3.27	-76.62	(*132*)
Santa Marta Batholith. (granodiorite)	34.2	1.6	Ar/Ar Kfs	11.24	-74.02	(*132*)
Dibulla Gneiss (anorthosite)	35	3	Ar/Ar Hb	10.74	-74.08	(*132*)
Cocha Río Téllez Migmatitic Complex (gneissic granodiorite)	35	0.4	Ar/Ar Hb	0.81	-77.33	(*132*)
Santa Marta Schist (amphibolic schist)	36.2	5.1	K/Ar Hb	11.28	-74.15	(*132*)
Paja Fm. (mineralized vein)	36.4	0.1	Ar/Ar Ms	5.64	-74.14	(*132*)
Cocha Río Téllez Migmatitic Complex (gneissic granodiorite)	36.4	0.6	Ar/Ar Hb	0.81	-77.33	(*132*)
Santa Cecilia La Equis Complex (porphyritic basalt)	36.7	11.5	Ar/Ar	6.74	-76.39	(*132*)
Patía 29-Ra-002	37.1	1.7	Ar/Ar	1.98	-77.15	(*132*)
Paja Fm. (mineralized vain)	37.3	0.1	Ar/Ar wr	5.64	-74.14	(*132*)
Socorro Stock (granodiorite)	37.8	1.7	K/Ar Bt	10.79	-74.03	(*132*)
Santa Marta Batholith (granodiorite)	38.65	0.55	Ar/Ar.Kfs	11.24	-74.02	(*132*)
Santa Marta Schist. Fm. Concha (phyllite)	38.7	3.4	K/Ar wr	11.31	-74.13	(*132*)
Acandí Batholith (quartz-diorite)	38.9	3	K/Ar Ser	8.53	-77.42	(*132*)
Timbiquí Fm. (andesite)	38.9	4.3	K/Ar	2.29	-77.65	(*132*)
Río Napi Intrusives (Hb diorite)	39	2	K/Ar	2.49	-77.48	(*132*)
Grupo Diabásico (dolerite)	39		K/Ar	3.27	-76.62	(*132*)
Grupo Diabásico	39.65	3.47	Ar/Ar Hb	1.33	-77.46	(*132*)
Grupo Diabásico (lava)	40	2	K/Ar wr	12.23	-71.69	(*132*)
Piedrancha Batholith (granodiorite)	40.5	3	K/Ar Bt	1.23	-77.73	(*150*)
Cocha Río Téllez Migmatitic Complex (gneissic granodiorite)	40	0.5	Ar/Ar Hb	0.81	-77.33	(*132*)
Grupo Diabásico (dolerite)	40		K/Ar	3.27	-76.62	(*132*)
Santa Marta Batholith (granodiorite)	40.16	1.4	Ar/ArKfs	11.28	-73.90	(*132*)
Santa Marta Batholith (granodiorite)	40.2	1.45	Ar/ArKfs	11.28	-73.90	(*132*)
Santa Marta Batholith (granodiorite)	40.39	0.27	Ar/ArKfs	11.28	-73.90	(*132*)
Santa Schist Marta. Cinto Fm. (phyllite)	40.9	4.7	K/Ar wr	11.25	-74.18	(*132*)
Nudillales Stock (quartz-monzonite)	41	3	K/Ar wr	7.04	-76.32	(*132*)
Timbiquí Fm. (andesite)	41	1	K/Ar	2.20	-77.68	(*132*)
Los Cholos-Napi River Pluton (Hb bearing quartz-diorite)	41	4	K/Ar	2.46	-77.50	(*132*)
Basalt	41.4	8.6	Ar/Ar Pl	6.02	-76.26	(*132*)
Llanitos Latiandesite	41.5	1.8	K/Ar wr	7.07	-76.41	(*132*)
Timbiquí Fm. (andesite)	41.7	1.2	K/Ar	2.40	-77.57	(*132*)
Santa Marta Batholith (granodiorite)	41.78	0.83	Ar/Ar Kfs	11.27	-74.09	(*132*)
Patía 29-Ra-002	41.9	0.7	Ar/Ar	1.98	-77.15	(*132*)
Amaime Fm.	42	13	Ar/Ar wr	3.70	-76.18	(*132*)
Balsitas Pluton (andesite dike)	42.6	1.3	K/Ar	2.17	-77.70	(*132*)
Santa Marta Schist (biotite schist)	42.6	1.7	K/Ar Bt	10.99	-74.14	(*132*)
Mandé Batholith (porphyritic dacite)	42.7	0.9	K/Ar Ser	6.70	-76.50	(*132*)
Pórfido Pantanos (porphyritic dacite)	42.7	0.9	K/Ar Bt	6 42	-76 30	(*150*)
Río Napi Intrusives (Hb-bearing gabbro)	43	0.4	K/Ar	2.53	-77.45	(*132*)
Basalt	43.1	0.4	Ar/Ar Pl	6.02	-76.26	(*132*)

Santa Marta Batholith (granodiorite)	43.57	0.48	Ar/Ar Kfs	11.27	-74.09	(*132*)
Buriticá Andesite (andesite. porphyritic diorite)	43.8	4.3	K/Ar wr	6.70	-75.91	(*132*)
Santa Marta Batholith (granodiorite)	43.91	0.45	Ar/Ar Bt	11.28	-73.90	(*132*)
Santa Marta Batholith (granodiorite)	44	0.77	Ar/Ar Bt	11.28	-73.90	(*132*)
Río Napi Intrusives (Hb-bearing tonalite)	44	4	K/Ar	2.49	-77.49	(*132*)
Timbiquí Fm. (andesite)	44	1	K/Ar	2.18	-77.70	(*132*)
Santa Marta Schist (amphibolic schist)	44.1	2.7	K/Ar Hb	11.22	-73.89	(*132*)
Santa Marta Batholith (quartz-diorite)	44.1	1.6	K/Ar Bt	11.29	-73.97	(*132*)
Mandé Batholith (tonalite)	44.6	0.9	U/Pb LA–MC– ICP–MS Zrn	6.73	-76.52	(*132*)
Los Azules (ophiolite sequence + pillow lavas)	44.7	6	K/Ar wr	1.9	-77.00	(*150*)
Mandé Batholith (tonalite)	44.8	1.0	Ar/Ar Hb	6.81	-76.59	(*132*)
Sevilla Complex (schist)	44.8	0.4	Ar/Ar Bt	11.26	-73.62	(*132*)
Mandé Batholith. (tonalite)	45.3	1.2	U/Pb LA–MC– ICP–MS Zrn	6.72	-76.52	(*132*)
Grupo Diabásico (lava)	46	3	K/Ar wr	3.51	-76.53	(*150*)
Santa Marta Batholith (granodiorite)	46.01	0.41	Ar/Ar Bt	11.24	-74.02	(*132*)
Dibulla Gneiss (anorthosite)	46.1	1.4	Ar/Ar Hb	10.74	-74.08	(*132*)
Santa Marta Batholith (granodiorite)	46.32	0.67	Ar/Ar Bt	11.24	-74.02	(*132*)
Timbiquí Fm. (dike, andesite)	46.7	2	K/Ar	2.18	-77.70	(*132*)
Sabaletas Stock (gabbro, diorite)	46.9	8.1	Ar/Ar Hb	3.82	-76.60	(*132*)
Grupo Diabásico (dolerite)	47		K/Ar	3.27	-76.62	(*132*)
Mandé Batholith (tonalite)	47.1	2.5	K/Ar Hb			(*150*)
Santa Marta Schist (amphibolic schist)	47.4	2.4	K/Ar Hb	11.12	-74.05	(*132*)
Santa Marta Batholith (granodiorite)	47.75	0.60	Ar/Ar Hb	11.28	-73.90	(*132*)
Esquistos de Santa Marta (pegmatite)	47.8	1.9	K/Ar Ms	11.26	-74.15	(*132*)
Parashi Stock (quartzodiorite)	48	4	K/Ar Hb	12.23	-71.74	(*132*)
Balsitas Pluton (tonalite)	48	1	K/Ar	2.17	-77.69	(*132*)
Santa Marta Batholith (granodiorite)	48.04	0.77	Ar/Ar Hb	11.24	-74.02	(*132*)
Acandí Batholith (tonalite)	48.1	1	K/Ar Hb	8.20	-77.24	(*150*)
Acandí Batholith (tonalite)	48.1	1	K/Ar Ser	8.46	-77.36	(*132*)
Acandí Batholith (tonalite)	48.1	2	K/Ar Ser	8 20	-77.24	(*150*)
Santa Marta Batholith (granodiorite)	48.33	0.78	Ar/Ar Hb	11.24	-74.02	(*132*)
Santa Marta Batholith (granodiorite)	48.34	0.90	Ar/Ar Hb	11.28	-73.90	(*132*)
Timbiquí Fm. (porphyritic andesite)	48.4	4.8	K/Ar	2.29	-77.64	(*132*)
Buriticá Pluton (quartzodiorite)	48.4	1.8	K/Ar Bt	11.17	-73.73	(*132*)
Santa Marta Batholith (quartzodiorite)	48.8	1.7	K/Ar Hb	11.29	-73.97	(*132*)
Grupo Diabásico (pillow lava)	49.4	9.8	K (R)	1.6	-77.4	(*150*)
El Bosque Batholith (granodiorite)	49.1	1.7	K/Ar Bt	4.44	-75.08	(*150*)
Santa Marta Batholith (granodiorite)	49.45	0.75	Ar/Ar Bt	11.27	-74.09	(*132*)
Gneis de Dibulla (anorthosite)	49.8	1.1	Ar/Ar Bt	10.74	-74.08	(*132*)
Gabro de Rodrigo (Hb-Px bearing gabbro)	49.9	0.2	Ar/Ar Pl	6.12	-72.34	(*132*)
Santa Marta Batholith (granodiorite-tonalite)	50.12	0.76	U/Pb LA–ICP–MS Zrn	11.28	-73.90	(*132*)
Santa Marta Batholith (granodiorite)	50.42	1.05	Ar/Ar Hb	11.27	-74.09	(*132*)
Santa Marta Batholith (granodiorite–tonalite)	50.6	1.7	U/Pb LA–ICP–MS Zrn	11.31	-73.94	(*132*)
Santa Marta Batholith (granodiorite)	50.66	0.87	Ar/Ar Hb	11.27	-74.09	(*132*)
Santa Cecilia La Equis Complex (porphyritic basalt)	50.7	2.0	Ar/Ar volcanic glass	6.74	-76.39	(*132*)
Timbiquí Fm. (andesite)	50.7	2	K/Ar	2.18	-77.70	(*132*)
Plutón de Buriticá (tonalite- quartz-diorite)	50.8	1.5	U/Pb LA–ICP–MS Zrn	11.18	-73.73	(*132*)
Santa Marta Batholith (granodiorite)	50.91	0.8	Ar/Ar Bt	11.27	-74.09	(*132*)
Plutón El Salto (pegmatite)	51	1	K/Ar	2.21	-77.66	(*132*)
Esquistos de Santa Marta (amphibolic schist)	51	3.6	K/Ar Hb	11.01	-74.12	(*132*)
Timbiquí Fm. (porphyritic andesite)	51.5	1.5	K/Ar	2.21	-77.69	(*132*)
Arquía Complex (garnet-bearing amphibolite)	51.6	3.3	Ar/Ar Hb	4.38	-75.72	(*132*)
Gabbronorite	51.7	3.9	Ar/Ar wr	6.58	-76.59	(*132*)
Santa Marta Batholith, (applite dike)	52.28	0.65	U/Pb LA–ICP–MS Zrn	11.14	-74.12	(*132*)
Gabbronorite	52.7	3.2	Ar/Ar wr	6.58	-76.59	(*132*)
El Hatillo Stock (quartzodiorite)	53	1.8	K/Ar Bt	5.19	-75.00	(*150*)
Río Napi Intrusives (Hb-bearing tonalite)	53	5	K/Ar	2.52	-77.43	(*132*)
Grupo Diabásico (pillow lava)	53.2	4.6	K/Ar wr	1.6	-77.4	(*150*)

Santa Marta Batholith (applite dike)	53.3	1.0	U/Pb LA–ICP–MS Zrn	11.24	-74.06	(*132*)
Timbiquí Fm. (andesite)	53.4	3	K/Ar	2.19	-77.71	(*132*)
Gabbronorite	53.6	2.9	Ar/Ar wr	6.58	-76.59	(*132*)
Gneis de Dibulla (anorthosite)	53.8	0.7	Ar/Ar Bt	10.74	-74.08	(*132*)
Sevilla Complex	53.9	0.5	Ar/Ar Bt	11.26	-73.62	(*132*)
Plutón Tucurinquita (granodiorite)	54	2.2	K/Ar Bt	10.68	-74.08	(*132*)
Sevilla Complex. (schist)	54.1	0.7	Ar/Ar Bt	11.26	-73.62	(*132*)
Gneis de Dibulla (anorthosite)	54.3	1.9	Ar/Ar Hb	10.74	-74.08	(*132*)
Esquistos de Santa Marta. Rodadero Fm. (amphibolite)	54.3	2.7	K/Ar Hb	11.20	-74.21	(*132*)
Esquistos de Jambaló (glaucophane blue schist)	54.5	1.6	Ar/Ar Pg	2.77	-76.33	(*132*)
Gneis de Dibulla (anorthosite)	54.5	0.8	Ar/Ar Bt	10.74	-74.08	(*132*)
El Hatillo Stock (quartz-diorite)	54.6	0.7	U/Pb LA–MC– ICP–MS Zrn	5.17	-74.97	(*30*)
Santa Marta Batholith (applite dike)	54.69	0.69	U/Pb LA–ICP–MS Zrn	11.27	-74.09	(*132*)
Gneis de Dibulla (anorthosite)	54.7	4	Ar/Ar Hb	10.74	-74.08	(*132*)
Mandé Batholith (tonalite)	54.7	1.3	K/Ar Hb	7.05	-76.75	(*132*)
Pórfido de Murindó (porphyry tonalite)	54.7	1.3	K/Ar Bt	7.03	-76.45	(*150*)
Florencia Stock (quartz-diorite)	54.9	1.9	K/Ar Bt	5.53	-75.05	(*132*)
Florencia Stock (quartz-diorite)	54.9	1.9	K/Ar Bt	5.37	-75.01	(*150*)
Santa Bárbara Batholith (diorite)	55	1	K/Ar Bt	3.37	-76.13	(*132*)
Santa Cecilia La Equis Complex (porphyritic basalt)	55.1	1.5	Ar/Ar	6.74	-76.39	(*132*)
Santa Marta Batholith (granodiorite– (tonalite)	55.05	1.05	U/Pb LA–ICP–MS Zrn	11.20	-74.10	(*132*)
Santa Marta Batholith (granodiorite–tonalite)	55.34	0.60	U/Pb LA–ICP–MS Zrn	11.17	-74.17	(*132*)
Gneis de Dibulla (anorthosite)	55.4	0.7	Ar/Ar Bt	10.74	-74.08	(*132*)
Santa Marta Batholith (granodiorite–tonalite)	55.52	0.34	U/Pb LA–ICP–MS Zrn	11.27	-74.09	(*132*)
Sonsón Batholith (leucogranite)	55.8	1	U/Pb LA–MC–ICP–MS Zrn	5.66	-75.20	(*132*)
Dike (andesite-dacite)	55.9	2	K/Ar Ser	6.45	-74.63	(*132*)
Santa Marta Batholith (dike)	55.9	0.29	U/Pb LA–ICP–MS Zrn	11.21	-74.24	(*132*)
Piedrancha Batholith (micro diorite)	57.7	3	K/Ar Bt	1.12	-77.86	(*150*)
Pórfido Rio Manso (quartz diorite. porphyry)	58	10	K/Ar Hb	4.11	-75.25	(*150*)
Stock Mainzales	59.8	0.7	U/Pb LA–MC–ICP–MS Zrn	5.12	-75.29	(*30*)

text S1. Estimation of date of splitting from molecular divergence

We used data from fossil calibrated molecular phylogenies published until 2015. Median and 95% HPDs of node ages were taken from the original publications if BEAST (*151, 152*) was used in divergence dating analyses. To avoid circularity we compiled molecular divergence dates from datasets that did not rely on the final closure of the Isthmus of Panama for calibration. Because we are interested in the time of the most recent common ancestor (TMRCA) of species, rather than of particular genes, we further restricted our choice to phylogenies that were based on a combination of DNA regions.

Our final dataset was compiled from 17 studies, and contains information on divergence times for 37 splits (table S3), 12 from fishes, 13 from gastropods, 10 from bivalves, and 2 from echinoids. In two cases, a new BEAST (v. 1.8.2) analysis was performed, because previous analyses did not use BEAST, or additional sequences were available. PartitionFinder v1.1.1 (*153*) was used to determine best partitioning scheme and model sequence evolution for each partition. The BEAST analysis used an uncorrelated lognormal relaxed clock (*154*). Details of each re-analysis were as follows.

Genus *Nerita*: The original analysis (*155*) employed (*156*) to infer divergence dates. The partitioned dataset was analyzed using exponential priors on fossil calibrations. We used Frey and Vermeij (*155*) fossil calibrations as minimum offsets for the exponential distributions, and specified a mean of the exponential distribution that produced a 95% HPD which included the next oldest node on the phylogeny, as estimated in the original paper. Dates were estimated based on Frey and Vermeij (*155*) tree topology with branch lengths estimated by BEAST. The analysis was run three times, each with 50,000,000 generations, sampling every 1,000th tree. Convergence of the posterior distribution was assessed using Tracer v.1.5 (*157*), with ESS values >250 indicating successful convergence.

Arcid bivalves: We combined and re-analyzed the data of Marko (*158*) and Marko and Moran (*159*). A new nucleotide alignment was produced that incorporated data from COI and H3. Exponential priors were placed on the fossil calibrations with distributions encompassing those described in Marko (*158*). We re-estimated the topology as well as the divergence times. The analysis was run three times for 50,000,000 generations, sampling every 1,000 trees. Convergence of the posterior distribution was assessed using Tracer v.1.5 with ESS values >250 indicating successful convergence. Convergence of the tree topology was assessed using the “cumulative” and “compare” functions implemented in AWTY (*160*).

table S3. Median and 95% HPD intervals of the time at which members of clades spanning the Isthmus of Panama were separated from each other as estimated by BEAST (151) from phylogenies calibrated by fossils at one or more nodes. Clades; 1 = Teleostei, 2 = Gastropoda, 3 = Bivalvia, 4 = Echinodermata. Contractions of gene names: CYTB: Cytochrome Oxidase B; 16S: Large subunit rDNA; 12S: Small subunit rDNA; COI: Cytochrome Oxidase I; ND3: NADH dehygrogenase 3; S7II: ribosomal protein involved in S16 assembly; ETS2: transcription factor involved in cell proliferation; TMO-4C4: Anonymous protein-coding locus; MYH6: cardiac muscle myosin heavy chain 6; RAG1 and RAG2: recombination activating gene 1 and 2; Rh: Rhodopsin; BMP4: bone morphogenetic protein 4; PTR: Pulmonary tumor resistance gene; ENC1: Ectodermal-neural contex 1; SREB: Brain super conserved receptor; GLYT: Clycosyltransferase; ATPSa: ATP Synthetase subunit alpha; H3: Histone 3.

Pair	Clade	Number on Fig. 3	Median estimate (Ma)	Low 95% HPD (Ma)	High 95% HPD (Ma)	Genes	Ref.
Mellita quinquiesperforata vs. *(M. notabilis, M. kanakoffi)*	4	1	3.21	2.51	3.91	COI 16S 28S	(*161*)
Chaetodon humeralis vs. *C. ocellatus*	1	2	3.40	1.80	5.40	CYTB S7II ETS2	(*162*)
Mycteroperca jordani vs. *(M. bonaci, M. venenosa))*	1	3	3.58	1.90	5.51	COI 16S TMO-4C4 S7	(*163*)
Conus gladiator vs. *C. mus*	2	4	4.10	2.90	5.80	16S calmodulin	(*164*)
Conus ermineus vs. *C. purpurascens*	2	5	4.20	1.50	7.50	16S calmodulin	(*164*)
Scarus hoefleri vs. *S. perrico*	1	6	4.82	2.46	7.70	16S S7	(*163*)
Balistes capriscus vs. *B. polylepis*	1	7	4.97	3.14	7.13	COI CYTB MYH6 RAG1 Rh	(*165*)
(Mellita longifissa, M. grantii) vs. *(M. isometra, M. tenuis, M. quinquiesperforata)*	4	8	5.46	4.40	6.50	COI 16S 28S	(*161*)
Chromis alta vs. *C. enchrysura*	1	9	5.57	3.03	8.81	12S 16S ND3 COI CYTB RAG1 RAG2 BMP4	(*166*)
Dallocardia senticosum vs. *Acrosterigma magnum*	3	10	6.00	2.00	13.00	16S H3 28S	(*167*)
Stegastes rectifraenum vs. *S. imbricatus*	1	11	6.19	3.17	9.63	12S 16S ND3 RAG1 RAG2 BMP4	(*166*)
Sargocentron suborbitalis vs. *S. vexillarium*	1	12	6.20	3.90	10.80	COI MYH6 PTR ENC1 RAG1 SREB GLYT	(*168*)
Microspathodon chrysurus vs. *M. dorsalis*	1	13	6.56	2.75	11.53	12S 16S ND3 RAG1 RAG2 BMP4	(*166*)
Calamus brachysomus vs. *C. nodosus*	1	14	8.00	2.00	16.00	COI CYTB 16S RAG1 Rh	(*169*)

Plectrypops lima vs. *P. retrospinis*	1	15	8.10	4.80	11.60	COI MYH6 PTR ENC1 RAG1 SREB GLYT	(*168*)
Littoraria irrorata vs. *L. variegata*	2	16	8.50	4.50	12.50	COI 12S 28S	(*170*)
Pomacanthus zonipectus vs. *(P. paru, P. arcuatus)*	1	17	8.60	5.00	12.3	12S 16S S7	(*171*)
Arcopsis adamsi vs. *A. solida*	3	18	8.87	3.78	15.36	COI H3	(*152, 158, 159*)
Conus perplexus vs. *C. puncticulatus*	2	19	8.90	5.00	19.00	16S calmodulin	(*164*)
Conus regius vs. *(C. bartschii, C. brunneus)*	2	20	9.20	5.00	14.90	16S calmodulin	(*164*)
Barbatia candida vs. *B. reeveana*	3	21	9.54	3.39	16.62	COI H3	(*152, 158, 159*)
Stegastes flavilatus vs. *((((S. diencaeus, S. fuscus),S. adustus),(S. variabilis,S. leucostictus))*	1	22	9.61	6.56	13.18	12S 16S ND3 COI RAG1 RAG2 BMP4	(*166*)
(Echinolittorina apicina, E. paytensis) vs. *E. risei*	2	23	10.36	6.83	13.96	COI 12S 28S	(*164*)
(Echinolittorina aspera, E. dubiosa, E. tenuistriata) vs. *E. interrupta*	2	24	10.75	7.39	14.35	COI 12S 28S	(*164*)
(Echinolittorina modesta, E. conspersa) vs. *(E. ziczac, E. ziczac (=E. soroziczac))*	2	25	10.87	7.52	14.42	COI 12S 28S	(*164*)
Barbatia illota vs. *B. tenera*	3	26	11.23	5.09	18.87	COI H3	(*152, 158, 159*)
Trachycardium egmontianum vs. *Phlogocardium belcheri*	3	27	12.00	5.50	20.00	16S H3 28S	(*167*)
Laevicardium pictum vs. *L. elenense*	3	28	12.50	5.00	22.50	16S H3 28S	(*167*)
Papyridea aspersa vs. *P. semisulcata*	3	29	16.00	8.00	24.50	16S H3 28S	(*167*)
(Bulla gouldiana, B. punctulata) vs. *B. mabillei*	2	30	16.80	7.20	31.70	COI 16S 28S	(*172*)
Nerita scabricosta vs. *(N. peloronta, N. versicolor)*	2	31	19.29	16.00	24.24	COI 16S ATPSa	(*155*)
Anadara chemnitzii vs. *A. nux*	3	32	20.95	10.69	32.21	COI H3	(*152, 158, 159*)
Amercardia media vs. *(Apiocardia obovalis, Trigoniocardia granifera)*	3	33	21.00	9.00	30.00	16S H3 28S	(*167*)
Echinolittorina galapagensis vs. *(E. tuberculata, E. vermeiji, E. miliaris, E. helenae, E. grandiosa)*	2	34	21.31	16.39	26.09	COI 12S 28S	(*164*)

Nerita funiculata, vs. *(N. tessellata, N. fulgurans, N. senegalensis)*	2	35	21.80	17.13	28.16	COI 16S ATPSa	(*155*)
Littoraria rosewateri vs. *L. tessellata*	2	36	24.20	15.00	32.50	COI 12S 28S	(*170*)
Littoraria nebulosa vs. *(L. varia, L. zebra, L. irrorata, L. variegata)*	2	37	25.70	18.00	33.00	COI 12S 28S	(*170*)
Arca mutabilis vs. *A. imbricata*	3	38	27.50	12.38	44.42	COI H3	(*152, 158, 159*)

table S4. Kimura two-parameter distance between mitochondrial genes of sister clades on either side of the Isthmus of Panama. Comparisons based on the control region were excluded, as this region is known to evolve at much faster rates. When sister clades included subclades, mean distance is shown. Age of separation of pairs in which phylogenies were calibrated by fossils are derived from BEAST (table S3). Age of separation of pairs in which there is no fossil calibration are estimated from average taxon-specific rates derived from other pairs with fossil-calibrated phylogenies. Age of separation of crustaceans, in which there are no fossil-calibrated phylogenies, are estimated from average rates over all taxa with fossil calibrated phylogenies

Taxon / clade	Mean divergence of all genes	Divergence rate from fossil calibration	Age of separation	COI	ATP8	ATP6	CytB	COII	COIII	ND1	ND2	ND3	ND4	ND4L	ND5	ND6	12S	16S	ref.
	%	%/Myr	Ma	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	
Calibration from fossils																			
Fishes																			
Chaetodon humeralis vs. *Chaetodon ocellatus*	10.25	3.01	3.40				10.25												(*162*)
Mycteroperca jordani vs. *(M. bonaci,M. venenosa))*	2.72	0.76	3.58	4.84													1.61	1.70	(*163*)
Scarus hoefleri vs. *Scarus perrico*	3.16	0.66	4.82															3.16	(*163*)
Balistes capriscus vs. *Balistes polylepis*	10.87	2.19	4.97	11.11			10.63												(*165*)
Chromis alta vs. *Chromis enchrysura*	3.60	0.65	5.57	5.81			7.91					2.26					1.22	0.80	(*166*)
Stegastes rectifraenum vs. *Stegastes imbricatus*	4.30	0.70	6.19									5.14					4.08	3.69	(*166*)
Sargocentron suborbitalis vs. *Sargocentron vexillarium*	5.61	0.90	6.20	5.61															(*168*)
Microspathodon chrysurus vs. *Microspathodon dorsalis*	4.31	0.66	6.56									8.22					2.03	2.68	(*166*)
Calamus brachysomus vs. *Calamus nodosus*	9.97	1.25	8.00	9.69			17.20											3.02	(*169*)
Plectrypops lima vs. *Plectrypops retrospinis*	9.26	1.14	8.10	9.26															(*168*)
Pomacanthus zonipectus vs. *(Pomacanthus paru, Pomacanthus arcuatus)*	2.10	0.24	8.60														2.10		(*171*)
Stegastes flavilatus vs. *((((S. diencaeus, S. fuscus),S. adustus),(S. variabilis,S. leucostictus))*	10.53	1.10	9.61	9.97								18.95					6.55	6.66	(*166*)
Median	4.96	0.83	6.20	9.26	-	-	10.44	-	-	-	-	6.68	-	-	-	-	2.07	3.02	
Minimum	2.10	0.24	3.40	4.84	-	-	7.91	-	-	-	-	2.26	-	-	-	-	1.22	0.80	
Maximum	10.87	3.01	9.61	11.11	-	-	17.20	-	-	-	-	18.95	-	-	-	-	6.55	6.66	
Gastropods																			
Conus gladiator vs. *(E. mus, E. tabidus)*	4.90	1.20	4.10	9.20														0.60	(*164, 173*)
Conus ermineus vs. *C. purpurascens*	3.75	0.89	4.20	5.39														2.10	(*164, 174*)

Littoraria irrorata vs. *L. variegata*	6.13	0.72	8.50	8.91													3.34		(*170*)
Conus perplexus vs. *puncticulatus*	9.31	1.05	8.90	12.22														6.40	(*164, 174*)
Conus regius vs. *(C. bartschii, C. brunneus)*	10.59	1.15	9.20	15.40														5.77	(*164*)
(Echinolittorina apicina, E. paytensis) vs. *E. riisei*	11.15	1.08	10.36	15.20													7.10		(*164, 173*)
(Echinolittorina aspera (E. dubiosa, E. tenuistriata)) vs. *E. interrupta*	7.95	0.74	10.75	11.40													4.50		(*164*)
*(Echinolittorina modesta, E.compresa)*vs. *(E. ziczac, E. ziczac(=E. soroziczac))*	8.30	0.76	10.87	11.70													4.90		(*164*)
(Bulla gouldiana, B. punctulata) vs. *B. mabillei*	7.87	0.47	16.80	13.22														2.51	(*172*)
Nerita scabricosta vs. *(N. peloronta, N. versicolor)*	9.43	0.49	19.29	13.75														5.10	(*155*)
Echinolittorina galapagiensis vs. *(((E. tuberculata, E. vermeiji) (E. granosa (E. miliaris, E. helenae)))*	11.45	0.54	21.31	14.00													8.90		(*164*)
Nerita funiculata, vs. *(N. tessellata, N. fulgurans, N. senegalensis)*	7.03	0.32	21.80	10.16														3.90	(*155*)
Littoraria rosewateri vs. *L. tessellata*	11.30	0.47	24.20	14.20													8.39		(*170*)
Littoraria nebulosa vs. *(L. varia, L. zebra, L. irrorara, L. variegata)*	10.15	0.39	25.70	13.30													7.00		(*170*)
Median	8.81	0.73	10.81	12.72	-	-	-	-	-	-	-	-	-	-	-	-	7.00	3.90	
Minimum	3.75	0.32	4.10	5.39	-	-	-	-	-	-	-	-	-	-	-	-	3.34	0.60	
Maximum	11.45	1.20	25.70	15.40	-	-	-	-	-	-	-	-	-	-	-	-	8.90	6.40	
Bivalves			-																
Dallocardia senticosum vs. *Acrosterigma magnum*	7.95	1.33	6.00															7.95	(*167*)
Arcopsis adamsi vs. *A. solida*	40.12	4.52	8.87	40.12															(*158, 159*)
Barbatia candida vs. *B. reeveana*	13.99	1.47	9.54	13.99															(*158, 159*)
Barbatia illota vs. *B. tenera*	16.02	1.43	11.23	16.02															(*158, 159*)
Trachycardium egmontianum vs. *Phlogocardium belcheri*	13.87	1.16	12.00															13.87	(*167*)
Laevicardium pictum vs. *Laevicardium elenense*	15.13	1.21	12.50															15.13	(*167*)
Papyridea aspersa vs. *Papyridea semisulcata*	26.64	1.67	16.00															26.64	(*167*)
Anadara chemnitzii vs. *A. nux*	24.69	1.18	20.95	24.69															(*158, 159*)
Amercardia media vs. *(Apiocardia abovalis, Trigoniocardia granifera)*	17.82	0.85	21.00															17.82	(*167*)
Arca mutabilis vs. *A. imbricata*	30.08	1.09	27.50	30.08															(*158, 159*)
Median	16.92	1.27	12.25	24.69														15.13	
Minimum	7.95	0.85	6.00	13.99														7.95	

Maximum	40.12	4.52	27.50	40.12						26.64	
Echinoids			-								
Mellita quinquiesperforata vs. *(M. notabilis, M kanakoffi)*	13.58	4.23	3.21	18.7						8.46	(*161*)
(Mellita longifissa, M. grantii) vs. *(M. isometra, M. tenuis, M. quinquiesperforata)*	24.47	4.48	5.46	39.76						9.18	(*161*)
Median	19.03	4.36	4.34	29.23						8.82	
Minimum	13.58	4.23	3.21	18.70						8.46	
Maximum	24.47	4.48	5.46	39.76						9.18	
Overall Median	**10.06**	**1.06**	**9.05**	**12.72**							
Overall Minimum	**2.10**	**0.24**	**3.21**	**4.84**							
Overall Maximum	**40.12**	**4.52**	**27.50**	**40.12**							
No fossil calibration											
Fishes											
Diodon hystrix vs. *D. hystrix*	0.20			0.60	0.00	0.00					(*3, 175*)
Melichthys niger vs. *M. niger*	0.40			0.20	0.60	0.40					(*3, 175*)
Alutera scripta vs. *A. scripta*	0.43			0.90	0.30	0.10					(*3, 175*)
Diodon holacanthus vs. *D. holacanthus*	0.45				0.30	0.60					(*3*)
Mulloidichthys martinicus vs. *(M. dentatus, M. vanicolensis, M. mimicus)*	0.70			1.30	0.10	0.70					(*69*)
(Epinephelus clippertonensis, E. labriformis) vs. *E. adscencionis*	0.90								0.90		(*176*)
Abudefduf concolor vs. *A. taurus*	1.33			1.40	0.60	1.60	1.70				(*3, 177*)
Anisotremus interruptus vs. *A. surinamensis*	1.57			1.60	1.20	1.90	2.90			0.27	(*175, 178-180*)
Centropomus medius vs. *C. pectinatus*	1.60									1.60	(*181*)
Lutjanus cempechanus vs. *L. peru*	1.77			1.56			1.97	1.78			(*182*)
Cephalopholis panamensis vs. *C. cruentatus*	1.90								1.20	2.60	(*176*)
Lutjanus argentiventris vs. *L. jocu*	2.15			0.88			2.98	2.60			(*182*)
Lutjanus cyanopterus vs. *L. novemfasciatus*	2.41			2.35			2.51	2.36			(*182*)
Anisotremus taeniatus vs. *A. virginicus*	3.11			4.40	3.70	3.80	3.23			0.43	(*175, 178-180*)
Abudefduf troshelii vs. *A. saxatilis*	3.40			4.50	0.00	4.30	4.80				(*177, 183*)
Sphyrna tiburo vs *S. tiburo*	3.50						3.50				(*184*)

Gerres cinereus vs. *G. cinereus*	3.90				5.10	2.70	3.90													(*3, 175, 185*)
Holacanthus passer vs. *H. ciliaris*	3.97				4.90	1.20	5.80													(*3, 175, 186*)
Rypticus bicolor vs. *R. saponaceus*	4.20				3.20	5.40	4.60	3.60												(*175, 185, 187*)
Lutjanus synagris vs. *L. guttatus*	4.54				1.88			5.33						6.40						(*182*)
Dermatolepis dermatolepis vs. *D. inermis*	4.60							8.20										1.00		(*188*)
Chaetodipterus zonatus vs. *C. faber*	4.70					6.40	3.00													(*3, 185*)
(Tylosurus melanotus, T. pacificus) vs. *(T. a. rafale (T. a. imperialis, T. a. acus))*	4.77					4.20	5.70	4.40												(*189*)
Halichoeres nicholsi vs. *((H. bivittatus, H. garnoti) (H. radiatus, H. poeyi))*	4.80				7.10													2.50		(*190*)
(Hippocampus ingens, H. fisheri) vs. *(H. reidi, H. algiricus)*	5.10							5.10												(*191*)
(Alphistes immaculatus, A. multigutattus) vs. *A. afer*	5.20							7.20										3.20		(*176, 188*)
Scorpaena mystes vs. *S. plumieri*	5.50				5.50															(*175*)
Haeumulon steindachneri vs H. steindachneri	5.83				6.58			5.08												(*192*)
(Scomberomorus sierra, S. concolor) vs. *(S. regalis, S. brasiliensis)*	6.03					4.70	6.90					6.50								(*193*)
Halichoeres dispilus vs. *H. pictus*	7.15				10.20													4.10		(*190*)
Lutjanus inermis vs. *Ocyurus chrysurus*	7.29				4.63			7.07						10.17						(*182*)
Paranthias colonus vs. *P. furcifer*	7.83				4.80	19.60	6.70											0.20		(*3, 175, 176*)
Ophioblennius macclurei vs. *Ophioblennius steindachneri*	11.23				12.40	5.60	12.70	14.20												(*3, 175, 194*)
Nicholsina denticulata vs. *N. usta*	12.10							19.50										4.70		(*195-197*)
Strongylura exilis vs (S. marina, S. sp)	12.42					20.00	14.60	14.20										5.10	8.20	(*189*)
Evorthodus minutus vs. *E. lyricus*	13.50							13.50												(*198*)
Centropomus robalito vs. *C. ensiferus*	14.55															17.00	12.10			(*199*)
Strongylura scapularis vs S. fluviatilis	15.18					15.60	16.60	21.60										10.90	11.20	(*189*)
Heteropriacanthus cruentatus vs. *H. cruentatus*	18.93				10.70	25.20	20.90													(*3, 175*)
Acanthemblemaria betinensis vs. *Acanthembemaria exilispinus*	20.32				20.32															(*200*)
Crustaceans																				
Chthamalus "mexicanus" vs. *C. proteus*	0.60																		0.60	(*201*)
Petrolisthes armatus vs. *P. armatus*	1.60																		1.60	(*202*)
Callinectes toxotes vs. *C. sapidus*	1.95																	2.00	1.90	(*203*)

Euraphia eastropacensis vs. *E.rhizophorae*	2.30			2.30	(*201*)
Uca (Minuca) vocator vs. *U. vocator*	2.40			2.40	(*204*)
Callinectes arcuatus vs. *C. ornatus*	2.55		3.00	2.10	(*203*)
Petrolisthes galathinus vs. *P. galathinus*	3.70			3.70	(*202*)
Sesarma rhizophorae vs. *(S. reticulatum, S. sp nr. reticulatum, S. curacaoense)*	4.10	4.10			(*205*)
Petrolisthes tonsorius vs. *P. tonsorius*	4.90			4.90	(*202*)
Alpheus antepenultimus A vs. *A. chacei*	5.40	5.40			(*206*)
(Sesarma sulcatum, S. aequatoriale) vs. *S. crassipes*	6.20	6.20			(*205*)
Alpheus rostratus vs. *A. paracrinitus spot*	6.40	6.40			(*206*)
Petrolisthes glasselli vs. *P. rosariensis*	6.70			6.70	(*202*)
Alpheus colombiensis vs. *A. estuarensis*	6.80	6.80			(*206*)
Alpheus websteri vs. *A. websteri*	7.30	7.30			(*206*)
Alpheus cylindricus vs. *A. cylindricus*	8.70	8.70			(*206*)
Synalpheus brevicarpus vs. *S. brevicarpus*	8.70	8.70			(*207*)
Alpheus canalis-sp.B (blue) = millsae vs. *A. nuttingi*	9.40	9.40			(*206*)
Alpheus floridanus B' vs. *A. floridanus B*	9.40	9.40			(*206*)
Alpheus panamensis vs. *A. formosus-sp.A*	9.50	9.50			(*206*)
Alpheus paracrinitus no spot vs. *A. paracrinitus no spot*	9.50	9.50			(*206*)
Synalpheus digueti vs. *S. minus*	9.50	9.50			(*207*)
Alpheus bouvieri vs. *A. bouvieri*	11.00	11.00			(*206*)
Xiphopenaeus riveti vs. *X. sp. 2*	11.10	11.10			(*208*)
(Petrolisthes haigae, P. hirtispinosus) vs. *P. marginatus*	11.20			11.20	(*202*)
Alpheus malleator vs. *A. malleator*	11.50	11.50			(*206*)
Penaeus vannamei vs. *(P. duorarum (P. paulensis, P. setiferus)*	12.10	12.10			(*209*)
Synalpheus fritzmuelleri vs. *S. fritzmuelleri*	12.10	12.10			(*207*)
Alpheus umbo vs. *A. schmitti*	13.20	13.20			(*206*)
Alpheus saxidomus vs. *A. simus*	13.90	13.90			(*206*)
Alpheus floridanus A' vs. *A. floridanus A*	15.10	15.10			(*206*)
Alpheus normanni vs. *A. normanni Brazil*	15.50	15.50			(*206*)

Emerita rathbunae vs. *(E. brasiliensis (E. benedicti, E. talpoida))*	15.80	15.80															(*210*)
(Alpheus naos, A. aequus) vs. *A. christofferseni*	17.80	17.80															(*211*)
Alpheus cristulifrons vs. *A. cristulifrons*	18.90	18.90															(*206*)
Austinixa felipensis vs. *A. cristata clade*	19.50	19.50															(*212*)
Synalpheus bannerorum vs. *S. dominicensis*	22.60	22.60															(*207*)
Gastropods																	
Crepidula incurva "Peru" vs. *C. convexa "Bocas"*	5.95	8.60														3.30	(*213*)
Strombus peruvianus vs. *S. raninus*	7.40	7.40															(*214*)
Tegula verrucosa vs. *T. viridula*	7.60	7.60															(*215*)
Macrocypraea cervinetta vs. *(M. zebra, M. cervus)*	11.50	11.50															(*216*)
Strombus gracilior vs. *(S. alatus, S. pugilis)*	12.10	12.10															(*214*)
Elysia diomedea vs. *(E. crispata, E. clarki)*	12.95	14.70														11.20	(*217*)
Tegula corteziana vs. *T. fasciata*	13.70	15.80													11.60		(*218*)
Plicopurpura patula vs. *P. pansa*	16.00				16.00												(*219*)
Bivalves																	
Brachidontes semilaevis vs. *E. exustus-Gulf-Atlantic*	21.40	21.4															(*220*)
Brachidontes adamsianus vs. *E. exustus-W. Caribbean*	23.70	23.7															(*220*)
Echinoids																	
Meoma ventricosa grandis vs. *M. ventricosa*	4.50	4.50															(*221*)
Diadema mexicanum vs. *D. antillarum*	5.95	4.80	2.70	4.40	5.00	11.10	5.90	6.00	5.90	3.60	8.00	4.70	7.00	8.20			(3, *222*)
Astropyga pulvinata vs. *A. magnifica*	9.90	9.90															(*222*)
(Tripneustes depressus, T. gratilla) vs. *T. ventricosus*	11.83	8.70	10.10	16.70													(3, *223*)
Eucidaris thouarsi vs. *E. tribuloides*	12.84	9.50	8.10	8.60	14.00	10.30	12.80	13.60	14.40	18.40	14.30	10.90	17.00	15.00			(3, *224*)
Echinometra vanbrunti vs. *E. lucunter*	13.23	10.30	7.80	8.80		12.40	13.60	12.80	11.80	14.30	17.00	16.80	16.80	16.40			(*225*)
Arbacia spatuligera vs. *A. lixula*	13.50	13.50															(*226*)
Lytechinus semituburculatus vs. *(L. variegatus, L. williamsi)*	17.80	13.50	24.30	16.70	16.70												(*227*)