Ecography

ECOG-00020
Patiño, J., Guilhaumon, F., Whittaker, R. J., Triantis, K. A., Gradstein, S. R., Hedenäs, L., González-Mancebo, J. M. and Vanderpoorten, A. 2012. Accounting for data heterogeneity in patterns of biodiversity: an application of linear mixed effect models to the oceanic island biogeography of spore-producing plants. – Ecography 35: xxx–xxx.

Supplementary material

Appendix 1. Literature sources for data about geological age of islands.

Archipelago	Islands	Reference	Observation
Azores	Corvo, Faial, Flores, Graciosa, Pico, San Jorge, Santa Maria, Sao Miguel, Terceira	França, Z. et al. 2003. Geologia dos Açores: Uma perspectiva actual. – Rev. Açoreana 10: 1–140. Borges, P. A. V. et al. 2009. Azores - Biology. – In: Gillespie, R. and Clague, D. A. (eds), Encyclopedia of Islands. University of California Press, pp. 70–75.	In the case of São Miguel. Johnson *et al.* (1998) suggest a much younger age (c. 0.8 Million years ago (Ma) as opposed to 4.01 Ma). However, we used the dates previously adopted by Borges *et al.* (2009).
Canary Islands	Alegranza, El Hierro, Fuerteventura, Graciosa, Gran Canaria, La Gomera, La Palma, Lanzarote, Montaña Clara, Tenerife	Anderson, C. L. et al. 2009. Life, death and fossilization on Gran Canaria – implications for Macaronesian biogeography and molecular dating. – J. Biogeogr. 36: 2189–2201. De la Nuez, J. et al. 1997. Los volcanes de los islotes al Norte de Lanzarote. – Fundación César Manrique. Carracedo, J. C. et al. 2001. Geology and volcanology of La Palma and El Hierro, Western Canaries. – Est. Geológ. 57: 175–273. Carracedo, J. C. et al. 2002. Cenozoic volcanism II: the Canary Islands. – In: Gibbons, W. and Moreno, T. (eds), The Geology of Spain. The 430 Geological Society, pp. 439–472. Marrero, A. and Francisco-Ortega, J. 2001. Evolución en islas: la forma en el tiempo. – In: Fernández-Palacios, J. M. and Martín Esquivel, J. L. (eds), Naturaleza de las islas Canarias: Ecología y conservación. Turquesa Ediciones, pp. 141–150.	De la Nuez et al. (1997) and Carracedo et al. (2001) for the smaller Canaries and Carracedo et al. (2002) for the seven main Canaries. In the case of Gran Canaria, we follow the recent work of Anderson et al. (2009) who discarded the complete sterilization of the island for plants after the Roque Nublo ash flow (Marrero and Francisco-Ortega 2001) on the base of Miocene–Pliocene rocks and fossil records; thus, we use the maximum subaerial age of Gran Canaria, which is estimated as c. 14.5 Ma (for review, see Fernández-Palacios et al. 2011).

Cape Verde	Boa Vista, Brava, Fogo, Sal, San Vicente, Santiago, Santo Antao, Sao Nicolau	Duarte, M. C. et al. 2008. Plant species richness in the Cape Verde Islands—eco-geographical determinants. – Biodivers. Conserv. 17: 453–466. Chiarucci, A. et al. 2011. Biogeographical determinants of pteridophytes and spermatophytes on oceanic archipelagos. – Syst. Biodiver. 9: 191–201.
Galápagos	Fernandina, Floreana, Isabela, Pinta, Pinzón, Rábida, San Cristóbal, Santa Cruz, Santiago	Peck, S. B. 1999. Physical correlates of insular species diversity: the insects of the Hawaiian Islands. – Annals Entomol. Soc. Am. 92: 529–536. Peck, S. B. 2005. The beetles (Insecta: Coleoptera) of the Galápagos Islands, Ecuador: evolution, ecology and diversity. – NRC Research Press.
Gulf Guinean	Annobon, ~~Bioko,~~ Principe, Sao Tome	Lee, D. C. et al. 1994. Isotopic variations with distances and time in the volcanic islands of the Cameroon line: evidence for mantle plume origin. – Earth Planet. Sci. Lett. 123: 119–139.
Hawaii	Hawaii, Kauai, Lanai, Maui, Molakai, Niiahu, Oahu	Clague, D. A. 1996. The growth and subsidence of the Hawaiian-Emperor volcanic chain. – In: Keast, A. and Miller, S. E. (eds), The origin and evolution of Pacific Island biotas. New Guinea to Eastern Polynesia: patterns and processes. SPB Academic Publishing BV, pp. 35–50. Price, J. P. 2004. Floristic biogeography of the Hawaiian Islands: influences of area, environment and paleogeography. – J. Biogeogr. 31: 487–500.

Juan Fernandez	Masatierra, Masafuera, Santa Clara	Haberle, S. 2009. Juan Fernandez islands. – In: Gillespie, R. and Clague, D. A. (eds), Encyclopedia of Islands. University of California Press, pp. 70–75.
Madeira	Desertas, Madeira, Porto Santo	Geldmacher, J. et al. 2005. New $^{40}Ar/^{39}Ar$ age and geochemical data from seamounts in the Canary and Madeira volcanic province: Support for the mantle plume hypothesis. – Earth Plan. Sci. Letters 237: 85–101.
Mascarenes	Mauritius, Reunion, Rodrigues	McDougall, I. and Chamalaun, F. G. 1969. Isotopic dating and geomagnetic polarity studies on volcanic rocks from Mauritius. Indian Ocean. – Geol. Soc. Am. Bull. 80: 1419–1442. Chevallier, L. and Vatin-Perignon, N. 1982. Volcano-structural evolution of Piton des Neiges, Reunion Island, Indian Ocean. – Bull. Volc. 45: 285–298. Fisk, M. R. et al. 1989. Reunion hotspot magma chemistry over the past 65 m.y.: results from Leg 115 of the Ocean Drilling Program. – Geology 17: 934-937.
Society	Moorea, Raiatea, Tahiti	Clouard, V. and Bonneville, A. 2005. Ages of seamounts, islands and plateaus on the Pacific Plate. – In: Foulger G. R. et al. (eds), Plates, plumes and paradigms. Geol. Soc. Am. Spec. Pap., pp. 71–90.

Tristan da Cunha	Gough, Inaccessible, Nightingale, Tristan da Cunha	Ryan, P. G. 2009. Tristan da Cunha and Gough Island. – In: Gillespie, R. and Clague, D. A. (eds), Encyclopedia of Islands. University of California Press, pp. 922–932.
Vanuatu	Efate, Erromango, Espiritu Santo, Futuna, Tanna	Marquet, G. et al. 2002. Biodiversity and biogeography of freshwater crustaceans (Decapoda: Natantia) from Vanuatu, a comparison with Fiji and New Caledonia. – Bull. Fr. Pêche Piscic. 364: 217-232. Peate, D. W. et al. 1997. Geochemical variations in Vanuatu Arc lavas: The role of subducted material and a variable mantle wedge composition. – J. Petrol. 38: 1331–1358.

Appendix 2. References used to document moss and liverwort species richness in the 12 investigated archipelagos.

Archipelago	Reference
Azores	Gabriel, R. et al. 2005. Lista dos briófitos (Bryophyta) [List of bryophytes (Bryophyta)]. – In: Borges, P. A. V. et al. (eds), Listagem da fauna (Mollusca e Arthropoda) e flora (Bryophyta, Pteridophyta e Spermatophyta) Terrestres dos Açores [A list of terrestrial fauna (Mollusca and Arthropoda) and flora. Direcçao Regional do Ambiente e Universidade dos Açores, pp. 117–129.
Canaries	Losada-Lima, A. et al. 2010. Bryophyta. – In: Arechavaleta, M. et al. (eds), Lista de especies silvestres de Canarias. Hongos, plantas y animales terrestres. Consejería de Medio ambiente y Ordenación Territorial. Gobierno de Canarias, pp. 106–119. For liverworts and mosses, we have used unpublished information to complete the species richness numbers, particularly from two the authors, J. Patiño and J.M. González-Mancebo.
Cape Verde	Patiño, J. and González–Mancebo, J. M. 2005. Bryophyta. – In: Arechavaleta, M. et al. (eds), Lista preliminar de especies silvestres de Cabo Verde (Hongos plantas y animales terrestres). Consejería de Medio ambiente y Ordenación Territorial. Gobierno de Canarias, pp. 34–37. For liverworts and mosses, we have used unpublished information to complete the species richness numbers, from J.M. González-Mancebo.
Galapagos	Gradstein, S. R. and Weber, W. A. 1982. Bryogeography of the Galapagos Islands. – J. Hattori Bot. Lab. 52: 127–155. For liverworts and mosses, we have used unpublished information to complete the species richness numbers, particularly from two the authors: S. R. Gradstein who has an article in process on the flora of liverworts, and F. Ziemmeck who has an article in process on the flora of liverworts and mosses.
Gulf Guinean islands	Sérgio, C. and Garcia, C. 2011. Bryophyte flora of São Tomé e Príncipe archipelago: annotated catalogue based on past researches. – Cryptog. Bryol. 32: 145–196. O'Shea, B. J. 2006. Checklist of the mosses of sub-Saharan Africa (version 5. 12/06). – Trop. Bryol. Res. Rep. 6: 1–252. Wigginton, M. J. 2009. Checklist and distribution of the liverworts and hornworts of sub-Saharan Africa, including the East African Islands

	(edition 3. January 2009). – Trop. Bryol. Res. Rep. 8: 1–116.
Hawaii	Staples, G. W. and Imada, C. T. 2006. Checklist of Hawaiian Anthocerotes and Hepatics. – Trop. Bryol. 28: 15-47. Staples, G. W. et al. 2004. A revised checklist of Hawaiian mosses. – Trop. Bryol. 25: 35–69. For liverworts, we have used unpublished information to complete and revise the species richness numbers, particularly from R. Gradstein, who has an article in process on the flora of liverworts.
Juan Fernandez	Brotherus, V. F. 1924. The Musci of the Juan Fernandez Islands. – Nat. Hist. Juan Fernandez Easter Islands 2: 409–448. Arnell, S. 1957. Hepaticae collected during Dr. and Mrs. Skottsberg's second expedition to the Juan Fernandez Islands. December 1954–March 1955. – Ark. Bot. 4: 1–21. Robinson, H. 1975. The Mosses of Juan Fernandez Islands. – Smithsonian Contribut. Bot. 27: 1-88. Matteri, C. M. 1984. Sinopsis de las especies Andino-patagónicas, Antárticas y Subantárticas de los géneros *Bartramia, Bartramidula* y *Conostomum* (Bartramiaceae, Musci). – Darwiniana 25: 143–162. Deguchi, H. 1991. A list of Moss Collection made during the Expeditions to Chile in 1981 and 1987 (2). – Bull. Nat. Sci. Mus., Series B, Bot. 17: 67-83. He, S. 1998. A Checklist of the mosses of Chile. – J. Hattori Bot. Lab. 85: 103–189. Müller, F. and Pursell, R. A. 2003. The genus *Fissidens* (Musci, Fissidentaceae) in Chile. – J. Hattori Bot. Lab. 93: 117–139. Haberle, S. 2009. Juan Fernández. – In: Gillespie, R. G. and Clague, D. A. (eds), Encyclopedia of Islands. University of California Press, pp. 507–509. Müller, F. 2009. An updated checklist of the mosses of Chile. – Archiv. Bryol. 58: 1–124.
Madeira	Kürschner, H. et al. 2008. New data on bryophytes from the Ilhas Desertas (Madeira Archipelago). – Nova Hedwigia 87: 529–543.

	Sérgio, C. et al. 2008. The bryophytes (Bryophyta) of the Madeira and Selvagens archipelagos. – In: Borges, P. A. V. et al. (eds), A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos. Direcçao Regional do Ambiente da Madeira and Universidade dos Açores, pp. 145–156. For liverworts and mosses, we have used unpublished information to complete the species richness numbers, particularly from J. Patiño, A. Vanderpoorten and J.M. González-Mancebo.
Mascarenes	Een, G. and Thingsgaard, K. 1999. Mosses from the Mascarenes - 7. A small collection from Rodrigues. – Trop. Bryol. 16: 3–10. Ah-Peng, C. and Bardat, J. 2005. Check list of the bryophytes of Réunion Island (France). – Trop. Bryol. 26: 89–118. O'Shea, B. J. 2006. Checklist of the mosses of sub-Saharan Africa (version 5. 12/06). – Trop. Bryol. Res. Rep. 6: 1–252. Ah-Peng, C. et al. 2008. Additions to the bryoflora of Réunion Island 2: Anthocerotopsida, Marchantiopsida and Jungermanniopsida from the herbarium of the National Botanic Garden of Belgium. – J. Bryol. 30: 185–191. Een, G. 2009. Moss Flora of the Island of Mauritius. – Trop. Bryol. 30:45–71. Frahm, J.-P. et al. 2009. The Moss Flora of Mauritius. – Arch. Bryol. 51: 1–26. Wigginton, M. J. 2009. Checklist and distribution of the liverworts and hornworts of sub-Saharan Africa, including the East African Islands. – Trop. Bryol. Res. Rep. 8: 1–116.
Society	Whittier, H. O. 1976. Mosses of the Society Islands. – Gainesville. Miller, H. A. et al. 1978. Prodromus Florae Muscorum Polynesiae. Bryophytorum Bibliotheca 16. – J. Cramer. Miller, H. A. et al. 1981. Prodromus Florae Hepaticarum Polynesiae, with key of genera. Bryophytorum Bibliotheca 25. – J. Cramer. Fok, E. 2009. Survey of Hepaticae (Liverworts) in Moorea. French Polynesia. – http://nature.berkeley.edu/classes/es196/projects/2009final/FokE_2009.pdf

Tristan da Cunha	Brown, R. N. R. 1905. The botany of Gough Island. – J. Linnean Soc. Bot. 37: 263–267. Wage, N. M. and Dickson, J. H. 1965. The Terrestrial Botany of the Tristan da Cunha Islands. – Phil. Trans. R. Soc. London, Series B. Bednarek-Ochyra, H. et al. 2000. The liverwort flora of Antarctica. – Polish Academy of Sciences.
Vanuatu ~~Vanuatu~~	Schultze-Motel, W. 1973. Katalog der Laubmoose von Melanesien. – Willdenowia 7: 47-81. Miller, H. A. et al. 1978. Prodromus Florae Muscorum Polynesiae. Bryophytorum Bibliotheca 16. – J. Cramer. Miller, H. A. et al. 1981. Prodromus Florae Hepaticarum Polynesiae, with key of genera. Bryophytorum Bibliotheca 25. – J. Cramer. Furuki, T. 2001. Studies on the Bryophyte Flora of Vanuatu. 5. Metzgeriales and Marchantiales (Hepaticae). – Annals Tsukuba Bot. Garden 21: 95–101. Streimann, H. and Reese, W. D. 2001. Vanuatu moss records. – J. Hattori Bot. Lab. 91: 295–300. Ellis, L. 2002. Studies on the Bryophyte Flora of Vanuatu. 2. Calymperaceae (Musci). – Annals Tsukuba Bot. Garden 21: 79–86. Hasegawa, J. 2002. Studies on the Bryophyte Flora of Vanuatu. 6. Anthocerotae. – Annals Tsukuba Bot. Garden 21: 103–107. Higuchi, M. 2002. Studies on the Bryophyte Flora of Vanuatu. 1. Introduction and Mniaceae (Musci). – Annals Tsukuba Bot. Garden 21: 73–77. Higuchi, M. 2002. Studies on the Bryophyte Flora of Vanuatu. 3. Fissidentaceae (Musci). – Annals Tsukuba Bot. Garden 21: 87–90. Higuchi, M. and Nishimura, N. 2002. Studies on the Bryophyte Flora of Vanuatu. 4. Hypnaceae (Musci). – Annals Tsukuba Bot. Garden 21: 91-94. Sass-Gyarmati, A. 2002. *Ptychanthoideae* (subfam. of *Lejeuneaceae*, *Hepaticae*) from Vanuatu, with the description of *Caudalejeunea streimannii* Gyarmati sp. n. – Trop. Bryol. 22: 125-134.

Vanuatu	Yamada, K. 2002. Notes on some Radula (Radulaceae, Hepaticae) species from Vanuatu. – Bryol. Res. 8: 102–103. Higuchi, M. 2003. Studies on the Bryophyte Flora of Vanuatu. 7. Stereophyllaceae (Musci). – Bull. Natl. Sci. Mus. Tokio Ser. B 29: 123–125. Yamada, K. 2003. Studies on the bryophyte flora of Vanuatu. 8. *Heteroscyphus* (Geocalycaceae, Hepaticae). – Bull. Natl. Sci. Mus. Ser. B 29: 149–152. Higuchi, M. 2005. Studies on the bryophyte flora of Vanuatu. 9. Field studies in 2000 and 2001 and Haplomitriaceae and Treubiaceae (Hepaticae). – Bull. Natl. Sci. Mus. Ser. B 31: 11–17. Higuchi, M. and Nishimura, N. 2006. Studies on the bryophyte flora of Vanuatu. 10. Additions to the Hypnaceae (Musci). – Bull. Natl. Sci. Mus. Tokyo Ser. B 32: 175–179. Higuchi, M. and Touw, A. 2008. Studies on the bryophyte flora of Vanuatu. 11. Anomodontaceae and Thuidiaceae (Musci). – Bull. Natl. Sci. Mus. Tokyo Ser. B 34: 113–118.

Appendix 3. AICc values for random effect model selection for (a) moss SR and (b) liverwort SR across the 12 archipelagos considered (n = 69). Models allowing or not for a varying intercept and all possible combinations of varying slopes for the different predictors considered: island areas (AREA), time elapsed since island formation (TIME, $TIME^2$), elevation (ELEV), distance to the closest continent (ISOL), and distance to the closest island within the archipelago (DIST). The best random effect structures (i.e. $\Delta AICc < 2$) are shown in bold and the 20 first models have been included. 'Zero' indicates that the parameter was not included in a given model.

a.

Intercept	AREA	TIME	$TIME^2$	ELEV	ISOL	DIST	AICc	ΔAICc
0	**1**	**0**	**0**	**0**	**0**	**0**	**251.3230**	**0.0000**
1	**0**	**0**	**0**	**0**	**0**	**0**	**251.5825**	**0.2595**
0	1	0	0	0	1	0	254.5127	3.1897
1	0	0	0	0	0	1	254.9287	3.6057
0	1	1	0	0	0	0	254.9428	3.6198
1	1	0	0	0	0	0	255.3286	4.0056
1	0	1	0	0	0	0	255.3802	4.0572
0	1	0	1	0	0	0	255.3902	4.0672
1	0	0	1	0	0	0	255.4566	4.1336
0	0	1	0	0	1	0	255.6958	4.3728
1	0	0	0	1	0	0	256.6875	5.3645
0	1	0	0	1	0	0	256.9651	5.6421
0	1	0	0	0	0	1	256.9651	5.6421
1	0	0	0	0	1	0	257.1911	5.8681
0	0	0	1	0	1	0	257.5581	6.2351
0	0	0	0	0	1	0	257.8206	6.4976
0	1	1	0	0	1	0	259.4490	8.1260
0	1	0	0	1	1	0	260.5656	9.2426
1	1	1	0	0	0	0	261.0670	9.7440
0	1	1	0	1	0	0	261.4583	10.1353

b.

Intercept	AREA	TIME	$TIME^2$	ELEV	ISOL	DIST	AICc	ΔAICc
1	**0**	**0**	**0**	**0**	**0**	**0**	**276.6332**	**0.0000**
1	1	0	0	0	0	0	280.1864	3.5532
0	1	0	0	0	0	0	280.2047	3.5715
1	0	0	1	0	0	0	280.2924	3.6592
1	0	1	0	0	0	0	280.8651	4.2319
1	0	0	0	1	0	0	281.2166	4.5835
0	0	1	0	0	0	1	281.3387	4.7055
1	0	0	0	0	0	1	281.8665	5.2333
0	0	0	1	0	0	1	282.7561	6.1229
0	1	0	1	0	0	0	283.4137	6.7805
0	1	1	0	0	0	0	283.6369	7.0037
0	0	0	0	0	0	1	283.8451	7.2120
0	1	0	0	0	0	1	284.4329	7.7997
0	1	0	0	0	1	0	285.8468	9.2136
0	1	0	0	1	0	0	285.8468	9.2136
1	1	0	1	0	0	0	286.9095	10.2764
1	1	1	0	0	0	0	287.1671	10.5340
1	1	0	0	0	0	1	287.4653	10.8321
1	1	0	0	0	1	0	287.4801	10.8470
1	0	1	0	0	1	0	288.3092	11.6761

Appendix 4. Coefficients for the fixed (geographical) factors included in the best random effect models used to predict moss and liverwort species richness (see Figure 1). The response variable SR for mosses (a, b) and liverworts (c) was log(n+1) transformed and explained by island area (AREA), island age (TIME, $TIME^2$), and elevation (ELEV). The mixed effect model including a random slope of AREA for mosses (a) and a random intercept among archipelagos for both mosses (b) and liverworts (c). The archipelagoes are sorted according to the value of the slope of area and intercept, respectively (from the lowest to the highest value).

	Archipelago	Intercept	AREA	TIME	$TIME^2$	ELEV
(a)	Cape Verde	1.6313	0.0775	0.0733	-0.0036	0.0005
	Galápagos	""	0.1244	""	""	""
	Hawaii	""	0.1570	""	""	""
	Vanuatu	""	0.2022	""	""	""
	Guinean Gulf islands	""	0.2583	""	""	""
	Canaries	""	0.3246	""	""	""
	Society	""	0.3565	""	""	""
	Mascarenes	""	0.3639	""	""	""
	Juan Fernandez	""	0.3854	""	""	""
	Tristan da Cunha	""	0.4016	""	""	""
	Madeira	""	0.4336	""	""	""
	Azores	""	0.4755	""	""	""
(b)	Cape Verde	0.5031	0.2552	0.0821	-0.0039	0.0006
	Hawaii	0.8240	""	""	""	""
	Galápagos	0.8341	""	""	""	""
	Vanuatu	1.3390	""	""	""	""
	Guinean Gulf islands	1.5821	""	""	""	""
	Juan Fernandez	1.6749	""	""	""	""
	Canaries	1.8156	""	""	""	""
	Society	2.1433	""	""	""	""
	Tristan da Cunha	2.1773	""	""	""	""
	Mascarenes	2.2207	""	""	""	""
	Madeira	2.4652	""	""	""	""
	Azores	2.7862	""	""	""	""
(c)	Cape Verde	-0.7344	0.2363	0.1234	-0.0048	0.0006
	Hawaii	0.0458	""	""	""	""
	Vanuatu	0.2764	""	""	""	""
	Canaries	0.4801	""	""	""	""
	Juan Fernandez	1.1542	""	""	""	""
	Galápagos	1.3459	""	""	""	""
	Guinean Gulf islands	1.6518	""	""	""	""
	Mascarenes	1.6817	""	""	""	""
	Madeira	1.9528	""	""	""	""
	Society	2.0463	""	""	""	""
	Tristan da Cunha	2.0729	""	""	""	""
	Azores	2.3259	""	""	""	""

""indicates that the values were identical for all the archipelagos.

Figure A1. Range of island ages (Ma) for all the archipelagos considered in the present study (Table 1). The islands were included according to the availability of species richness data for bryophyte floras, which does not preclude that a given archipelago may exhibit broader island age ranges.