Ecography

ECOG-01938
Arnan, X., Cerdá, X. and Retana, J. 2016. Relationships among taxonomic, functional, and phylogenetic ant diversity across the biogeographic regions of Europe. – Ecography doi: 10.1111/ecog.01938

Supplementary material

Appendix 1. Ant species list used in this study, number of communities within each biogeographic region (and overall) where they occur, and functional trait values for each species. Abbreviations: Med, Mediterranean; Con, Continental; Atl, Atlantic; Alp, Alpine; Bor, Boreal; n com, number of communities where the species occur; WS, worker size; WP, worker polymorphism; Diur, diurnality; Dom, behavioral dominance; pS, proportion of seeds in diet; pI, proportion of insects in diet; pLF, proportion of liquid food in diet; FSI, individual foraging strategy; FSG, group foraging strategy; FSC, collective foraging strategy; CS, colony size (ln-transformed); nQ, number of queens; nN, number of nests; CFT, colony foundation type. The states of the different functional traits are shown in Appendix 2.

SPECIES	Med	Con	Atl	Alp	Bor	n	WS	WP	Diur	Dom	pS	pI	pLF	FSI	FSG	FSC	CS	nQ	nN	CFT
Formicinae																				
Camponotus aethiops	66		1			67	7.50	0.67	0	1	0	0.25	0.75	0	1	0	7.47	0	0	1
Camponotus amaurus	1					1	6.10	0.69	1	0	0	0	1	0	1	0	5.99	0	1	1
Camponotus cruentatus	70					70	10.00	0.80	0	1	0	0.25	0.75	0	1	0	8.52	0	0	1
Camponotus gestroi	2					2	6.10	0.59	0	0	0	0	1	0	1	0	6.21	0	0	1
Camponotus fallax	18	2				20	6.90	0.41	0	0	0	0	1	0	1	0	6.21	0	0	1
Camponotus figaro	1					1	3.90	0.44	1	0	0	0	1	0	1	0	6.21	0	0	1
Camponotus foreli	27					27	6.10	0.69	1	0	0	0	1	0	1	0	5.99	0	1	1
Camponotus herculeanus				8	17	25	10.80	0.69	0	1	0	0.25	0.75	0	1	0	8.52	0.5	0	1
Camponotus lateralis	69					69	5.00	0.40	1	0	0	0	1	0	1	0	6.91	0	0	1
Camponotus ligniperdus	2	6	1	3	8	20	9.00	0.67	0	1	0	0.25	0.75	0	1	0	7.82	0.5	0	1
Camponotus micans	6					6	8.50	1.29	0		0	0	1	0	1	0	6.91	0	0	1
Camponotus piceus	62	1	1			64	3.90	0.44	1	0	0	0	1	0	1	0	6.21	0	0	1
Camponotus pilicornis	89					89	8.50	0.82	0	1	0	0	1	0	1	0	6.91	0	0	1

Camponotus sylvaticus	75					75	8.00	0.75	0	1	0	0	1	0	1	0	6.91	0	0	1
Camponotus truncatus	17	4				21	4.50	0.67	0	0	0	0	1	1	0	0	5.70	0	0	1
Camponotus vagus	3	3				6	9.40	0.68	0	1	0	0.25	0.75	0	1	0	7.82	1	0	1
Cataglyphis aenescens		4				4	5.55	0.88	1	0	0	1	0	1	0	0	6.91	0	0	1
Cataglyphis cursor	13					13	6.70	0.61	1	0	0	1	0	1	0	0	6.62	0	0	0
Cataglyphis floricola	12					12	6.00	0.22	1	0	0	1	0	1	0	0	5.52	0	0	0
Cataglyphis hispanica	5					5	8.50	0.93	1	0	0	1	0	1	0	0	6.62	0	0	0
Cataglyphis iberica	19					19	6.00	0.50	1	0	0	1	0	1	0	0	6.48	0	1	1
Cataglyphis rosenhaueri	15					15	6.00	0.50	1	0	0	1	0	1	0	0	6.40	0	1	1
Cataglyphis velox	12					12	8.30	0.90	1	0	0	1	0	1	0	0	6.62	0.5	0.5	0
Formica aquilonia					16	16	6.60	0.76	0	1	0	0.5	0.5	0	0	1	12.90	1	1	0
Formica cinerea		3	1	6		10	5.30	0.66	0	1	0	0.5	0.5	0	0	1	8.52	0.5	1	0
Formica clara				3		3	6.50	0.46	1	1	0	0.5	0.5	0	1	0	8.52	0	0	1
Formica cunicularia	16	24	10	4		54	5.30	0.47	1	0	0	0.5	0.5	0	1	0	7.24	0	0.5	1
Formica decipiens	1					1	5.60	0.41	1	0	0	0.5	0.5	0	1	0	7.13	0	0	1
Formica fusca	51	32	19	1	26	129	5.00	0.60	1	0	0	0.5	0.5	0	1	0	9.10	1	1	1
Formica gagates	48		1			49	5.00	0.60	1	0	0	0.5	0.5	0	1	0	6.21	0	0	1
Formica gerardi	14		1			15	5.50	0.36	1	0	0	0.5	0.5	0	1	0	7.13	0	0	1
Formica lemani	10			12	12	34	5.50	0.38	1	0	0	0.5	0.5	0	1	0	7.47	0	0	1
Formica lugubris	1		1	3	17	22	6.50	0.77	0	1	0	0.5	0.5	0	0	1	10.60	1	1	0.5
Formica lusatica		6				6	6.50	0.46	1	1	0	0.5	0.5	0	1	0	8.52	0	0	1
Formica nigricans	1					1	6.50	0.77	0	1	0	0.5	0.5	0	0	1	11.00	1	1	0
Formica polyctena		3	6		5	14	6.50	0.77	0	1	0	0.5	0.5	0	0	1	13.02	1	1	0
Formica pratensis	1	5	1	2	10	19	6.50	0.77	0	1	0	0.5	0.5	0	0	1	11.00	1	1	0
Formica rufa	2	3	11	2	11	29	6.50	0.77	0	1	0	0.5	0.5	0	0	1	9.21	1	1	0
Formica rufibarbis	15	15	6	1	4	41	6.00	0.50	1	0	0	0.5	0.5	0	1	0	6.91	0	0	1
Formica sanguinea	2	8	4	1	14	29	7.50	0.40	1	1	0	0.5	0.5	0	0	1	9.21	0.5	0	0.5
Formica subrufa	65					65	4.90	0.29	1	0	0	0.75	0.25	0	1	0	6.55	0	0	1
Formica transkaucasica		1	1		1	3	3.90	0.62	0	0	0	0.5	0.5	0	1	0	7.60	0	1	0
Formica truncorum		2			7	9	6.30	0.87	0	1	0	0.5	0.5	0	0	1	9.21	1	1	0
Formica uralensis					5	5	6.30	0.40	0	0	0	0.5	0.5	0	0	1		1	1	0
Lasius alienus	21	27	11			59	2.80	0.50	0	1	0	0.25	0.75	0	0	1	9.47	0	0	1

Lasius balcanicus		1				1	5.50	0.36	0		0	0.25	0.75	0	0	1	9.90	0	0	1
Lasius brunneus	10	18	1		1	30	2.90	0.62	0	0	0	0.25	0.75	0	0	1	9.21	0	0	1
Lasius cinereus	2					2	3.30	0.45	0	1	0	0	1	0	0	1	9.21	0	0	1
Lasius emarginatus	30	4	1			35	3.20	0.47	0	1	0	0.25	0.75	0	0	1	9.21	0	0	1
Lasius flavus	6	20	24	6	11	67	2.90	0.79	0	0	0	0.25	0.75	0	0	1	9.21	0.5	0	1
Lasius fuliginosus	5	5	10		1	21	4.00	0.50	0	1	0	0.25	0.75	0	0	1	14.73	0	0	0
Lasius grandis	10					10	3.50	0.57	0	1	0	0.25	0.75	0	0	1	9.21	0	0	1
Lasius lasioides	1					1	2.80	0.50	0	1	0	0.25	0.75	0	0	1	9.47	0	0	1
Lasius myops	39	4	2			45	2.90	0.79	0	0	0	0	1	0	0	1	8.52	0	0	1
Lasius niger	89	43	23	10	23	188	3.00	0.67	0	1	0	0.25	0.75	0	0	1	9.21	0	0	1
Lasius paralienus		3		1		4	4.50	0.44	0	1	0	0.25	0.75	0	0	1	9.21	0	0	1
Lasius psammophilus		1	1		1	3	3.40	0.59	0	0	0	0.25	0.75	0	0	1	10.43	0	1	1
Plagiolepis pygmaea	140	7				147	1.60	0.50	0	0	0	0	1	0	1	0	6.68	1	0.5	0
Plagiolepis schmitzii	37					37	2.10	0.48	1	0	0	0	1	0	1	0	6.68	1	0.5	0
Proformica ferreri	13					13	4.50	0.73	1	0	0	1	0	1	0	0	6.48	0	0	
Proformica nasuta	1					1	5.00	1.00	1	0	0	1	0	1	0	0	6.48	0	0	
Dolichoderinae																				
Dolichoderus quadripunctatus	9	4				13	3.50	0.29	0	0	0	0.5	0.5	0	0	1	6.11	0	1	0
Linepithema humile	5					5	2.30	0.22	0	1	0	0.25	0.75	0	0	1	11.92	1	1	0
Liometopum microcephalum		2				2	5.00	0.80	0	1	0	0.75	0.25	0	0	1	8.52	0	0	1
Tapinoma erraticum	29	12	3	4		48	2.80	0.54	0	1	0	0	1	0	0	1	8.16	1	1	0
Tapinoma nigerrimum	114		2			116	4.00	0.58	0	1	0	0	1	0	0	1	8.85	1	1	0
Tapinoma simrothi	2	9	1			12	3.20	0.44	0	1	0	0	1	0	0	1	8.85	1	1	0
Myrmicinae																				
Aphaenogaster dulcineae	20					20	6.00	0.33	0	0	0.5	0.5	0	0	1	0	6.48	0	0	
Aphaenogaster gibbosa	80		1			81	4.90	0.41	1	0	0.5	0.5	0	0	1	0	6.48	0	0	1
Aphaenogaster iberica	20					20	6.40	0.19	1	0	0.5	0.5	0	0	1	0	6.25	0	0	0
Aphaenogaster cardenai	1					1	6.70	0.10	0	0	0.5	0.5	0	0	1	0	8.01	0	0	1
Aphaenogaster senilis	61					61	7.00	0.14	1	0	0.5	0.5	0	0	1	0	6.48	0	0	0
Aphaenogaster subterranea	67		1			68	3.80	0.45	0	0	0.5	0.5	0	0	1	0	7.60	0	0	1
Cardiocondyla batesii	7					7	2.10	0.24	0	0	0	0.75	0.25	0	1	0	4.79	0	0	1

Cardiocondyla mauritanica	2					2	2.00	0.20	0	0	0	0.75	0.25	0	1	0	5.01	1	0	0
Crematogaster auberti	57					57	3.40	0.35	0	1	0	0	1	0	1	0	6.48	0	0	0
Crematogaster scutellaris	83					83	4.05	0.57	0	1	0	0.5	0.5	0	0	1	6.62	0.5	0.5	1
Crematogaster sordidula	52					52	2.45	0.37	0	1	0	0	1	0	1	0	6.62	0	0	1
Goniomma baeticum	2					2	4.10	0.24	0	0	1	0	0	1	0	0	5.86	0	0	1
Goniomma blanci	5					5	3.50	0.29	0	0	1	0	0	1	0	0	5.86	0	0	1
Goniomma collingwoodi	1					1	3.65	0.08	0	0	1	0	0	1	0	0	5.86	0	0	1
Goniomma hispanicum	24					24	3.90	0.21	0	0	1	0	0	1	0	0	5.86	0	0	1
Goniomma kugleri	1					1	3.10	0.19	0	0	1	0	0	1	0	0	5.89	0	0	1
Goniomma thoracicum	2					2	3.90	0.21	0	0	1	0	0	1	0	0	5.86	0	0	1
Leptothorax acervorum	1	6	13	7	21	48	3.60	0.17	0	0	0	0.5	0.5	0	1	0	7.60	1	0	0
Leptothorax gredleri		2				2	3.20	0.16	0	0	0	0.5	0.5	0	1	0	3.91	0	0	0.5
Leptothorax muscorum		4	9		14	27	2.90	0.55	0	0	0	0.5	0.5	0	1	0	5.70	1	0	0
Manica rubida		1		3		4	7.00	0.71	1	0	0	1	0	0	0	1	8.16	0.5	0	1
Messor barbarus	54					54	7.90	1.04	0	1	1	0	0	0	0	1	8.99	0	0	1
Messor celiae	2					2	7.90	1.04	0	1	1	0	0	0	0	1	8.99	0	0	1
Messor bouvieri	27					27	6.30	0.71	1	0	1	0	0	0	0	1	8.16	0	0	1
Messor maroccanus	23					23	6.30	0.71	1	0	1	0	0	0	0	1	8.16	0	0	1
Messor capitatus	41					41	8.40	1.07	0	1	1	0	0	0	1	0	8.29	0	0	1
Messor hispanicus	8					8	7.90	1.04	0	1	1	0	0	0	0	1	8.99	0	0	1
Messor lusitanicus	10					10	6.50	0.54	1	0	1	0	0	0	0	1	8.16	0	0	1
Messor structor	28					28	6.80	0.81	0	1	1	0	0	0	0	1	8.29	1	0	0
Monomorium salomonis	1					1	3.05	0.36	0	1	0.25	0.75	0	0	0	1	8.01	1	1	0
Myrmecina graminicola	18	14	3			35	3.05	0.36	0	0	0	0.75	0.25	1	0	0	4.61	0.5	0	0
Myrmica aloba	15					15	4.50	0.22	0	0	0	0.5	0.5	0	0	1	7.60	0	0	0.5
Myrmica hellenica				1		1			0	0	0	0.5	0.5	0	0	1	7.38	0.5	0	0.5
Myrmica lobulicornis	1	7		5	22	35	3.75	0.27	0	0	0	0.5	0.5	0	0	1	7.31	1	0	0.5
Myrmica lonae					3	3	4.40	0.14	0	0	0	0.5	0.5	0	0	1	8.01	1	0	0.5
Myrmica rubra		31	16	14	11	72	4.00	0.25	0		0	0.5	0.5	0	0	1	8.01	1	1	0.5
Myrmica ruginodis	2	35	16	16	27	96	4.75	0.11	0	0	0	0.5	0.5	0	0	1	7.60	0.5	0	0.5
Myrmica rugulosa		2				2	4.00	0.25	0	0	0	0.5	0.5	0	0	1	7.60	1	1	0.5
Myrmica sabuleti	13	39	21	2	3	78	4.40	0.14	0	0	0	0.5	0.5	0	0	1	8.01	1	0	0.5

Myrmica scabrinodis	10	31	21	10	23	95	4.25	0.24	0	0	0	0.5	0.5	0	0	1	7.31	0.5	0	0.5
Myrmica schencki	2	22	14	1	12	51	4.15	0.51	0	0	0	0.5	0.5	0	0	1	6.91	0.5	0	0.5
Myrmica specioides	1	9	7			17	5.60	0.18	0	0	0	0.5	0.5	0	0	1	7.31	1	0	0.5
Myrmica spinosior	2					2	4.40	0.14	0	0	0	0.5	0.5	0	0	1	8.01	1	0	0.5
Myrmica sulcinodis					12	12	4.75	0.32	0	0	0	0.5	0.5	0	0	1	6.68	0	0.5	0.5
Myrmica wesmaeli				3		3	3.80	0.26	0	0	0	0.5	0.5	0	0	1	7.31	1	0	0.5
Oxyopomyrmex saulcyi	15					15	2.00	0.20	0	0	1	0	0	1	0	0	4.61	0	0	1
Pheidole pallidula	132					132	3.20	1.03	0	1	0.25	0.75	0	0	0	1	8.52	0.5	0	0.5
Stenamma orousetti	1					1	3.30	0.18	0	0	0	1	0	1	0	0	4.61	0	0	1
Stenamma westwoodi	4	18				22	3.30	0.18	0	0	0	1	0	1	0	0	4.61	0	0	1
Stenamma petiolatum			1			1	4.50	0.13	0	0	0	1	0	1	0	0	4.61	0	0	1
Temnothorax angustulus	5					5	2.80	0.21	0	0	0	0.5	0.5	0	1	0	3.91	0	0	1
Temnothorax caesari	2					2	2.20	0.18	0	0	0	0.5	0.5	0	1	0	4.61	0	0	
Temnothorax clypeatus	1					1	3.00	0.33	0	0	0	0.5	0.5	0	1	0	4.61	0	0	1
Temnothorax crassispinus		5				5	2.90	0.41	0	0	0	0.5	0.5	0	1	0	4.61	0	0	0.5
Temnothorax exilis	3					3	2.60	0.46	0	0	0	0.5	0.5	0	1	0	3.91	0	0	1
Temnothorax fuentei	15					15	4.15	0.07	0	0	0	0.5	0.5	0	1	0	3.91	0	0	1
Temnothorax gredosi	1					1	2.50	0.32	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax grouvellei	1					1	2.85	0.46	0	0	0	0.5	0.5	0	1	0	4.61	0	0	1
Temnothorax interruptus		9	1			10	2.30	0.52	0	0	0	0.5	0.5	0	1	0	5.01	1	0	0
Temnothorax kraussei	13					13	2.80	0.21	0	0	0	0.5	0.5	0	1	0	3.91	0	0	1
Temnothorax lichtensteini	42					42	2.60	0.08	0	0	0	0.5	0.5	0	1	0	5.30	0	0	1
Temnothorax luteus	2		1			3	2.40	0.25	0	0	0	0.5	0.5	0	1	0		0	0	1
Temnothorax niger	20					20	2.65	0.34	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax nigriceps	1	3	1			5	2.65	0.26	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax nylanderi	49	19				68	2.65	0.30	0	0	0	0.5	0.5	0	1	0	5.70	0	0	1
Temnothorax pardoi	2					2	2.50	0.08	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax parvulus	4	5				9	2.45	0.12	1	0	0	0.5	0.5	0	1	0	6.40	0	0	1
Temnothorax rabaudi	36					36	2.70	0.22	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax racovitzai	67		1			68	2.55	0.12	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax recedens	37					37	2.70	0.30	1	0	0	0.5	0.5	0	1	0	5.01	0	0	0
Temnothorax specularis	36					36	2.35	0.13	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1

Temnothorax tristis	5					5	2.50	0.40	0	0	0	0.5	0.5	0	1	0	5.01	1	0	1
Temnothorax tuberum	2	11	1		2	16	2.85	0.39	0	0	0	0.5	0.5	0	1	0	5.30	0	0.5	1
Temnothorax thyndalei	17					17	2.65	0.19	0	0	0	0.5	0.5	0	1	0	5.01	0	0	1
Temnothorax unifasciatus	10	15	2			27	2.50	0.40	0	0	0	0.5	0.5	0	1	0	5.78	0	0	1
Tetramorium caespitum	90	22	27	5	6	150	2.90	0.41	0	1	0.25	0.75	0	0	0	1	9.21	0	0	1
Tetramorium impurum	3	6				9	2.90	0.41	0	1	0.25	0.75	0	0	0	1	9.21	0	0	1
Tetramorium forte	10					10	3.75	0.51	0	1	0.25	0.5	0.25	0	0	1	9.21	0	0	1
Tetramorium hispanicum	16		1			17	3.75	0.51	0	1	0.25	0.5	0.25	0	0	1	9.21	0	0	1
Tetramorium ruginode	10					10	3.75	0.51	0	1	0.25	0.5	0.25	0	0	1	9.21	0	0	1
Tetramorium semilaeve	80					80	3.60	0.33	0	1	0.25	0.75	0	0	0	1	9.21	1	0	1
Tetramorium punicum	2					2	3.60	0.33	0	1	0.25	0.75	0	0	0	1	9.21	1	0	1
Ponerinae																				
Hypoponera eduardi	4					4	2.85	0.18	0	0	0	1	0	0	1	0	7.31	1	0	1
Hypoponera punctatissima	1					1	3.15	0.16	0	0	0	1	0	0	1	0	5.01	1	1	0.5
Ponera coarctata	9	5	2			16	2.95	0.31	0	0	0	1	0	0	1	0	4.61	1	0	0
Pseudomyrmicinae																				
Tetraponera allaborans		1				1				0	0	0.75	0.25				6.62	0	0	0.5
Leptanillinae																				
Leptanilla revelieri	2					2	1.15	0.09	0	0	0	1	0	0	1	0	5.70	0	0	0

Appendix 2. Functional traits used to determine the functional diversity of the ant communities included in this study.

Trait	Data type	States
Worker size	Continuous	Worker body size from the tip of mandibles to tip of the gaster (mm)
Worker polymorphism	Continuous	Mean worker size divided by the range of worker size
Diurnality	Binary	(0) Non-strictly diurnal (1) Strictly diurnal
Behavioral dominance	Binary	(0) Subordinate (1) Dominant
Diet: Seed-eating, Insect-eating, and Liquid-food eating	Fuzzy-coded (*)	0-1 (for each of the three categories)
Foraging strategy: Individual, Group, and Collective (**)	Binary	0-1 (for each of the three categories)
Colony size	Continuous	Mean number of workers per colony
Number of queens	Ordinal	(0) Monogyny; (0.5) Both monogyny and polygyny; (1) Polygyny
Number of nests	Ordinal	(0) Monodomy; (0.5) Both monodomy and polydomy (1) Polydomy
Colony foundation type	Ordinal	(0) DCF; (0.5) Both DCF and ICF; (1) ICF

*Variable categories were coded using a fuzzy-coding technique. Scores ranged from '0' (no consumption of a food resource) to '1' (frequent consumption of a food resource).

**Individual: workers of these species are not able to communicate their nestmates the presence of a food source, they forage and collect food individually; Group: workers of these species are able to communicate and guide a low number of nestmates to a previously discovered food source; Collective: workers of these species follow "anonymous" chemical signals provided by other nestmates to exploit a food source, they can organize mass-recruitment or temporal or permanent trails to the food source

Appendix 3. List of references utilized to build the working phylogeny, phylogenetic signals present in ant functional traits, and phylogenetic tree for the 154 European ant species examined in this study.

List of references utilised to build the working phylogeny. References that used molecular data are indicated as *

(many of them have been obtained from AntWeb. Available from http://www.antweb.org. Accessed 10 January 2014)

Agosti D (1990) Review and reclassification of *Cataglyphis* (Hymenoptera, Formicidae). Journal of Natural History 24:1457-1505

* Beibl J, Buschinger A, Foitzik S, Heinze J (2007) Phylogeny and phylogeography of the Mediterranean species of the parasitic ant genus *Chalepoxenus* and its *Temnothorax* hosts. Insectes Sociaux 54:189-199

Bernard F 1950 ("1946"). Notes sur les fourmis de France. II. Peuplement des montagnes méridionales. Annales de la Société Entomologique de France 115:1-36

Bernard F (1968) Les Fourmis (Hymenoptera Formicidae) d'Europe Occidentales et Septentrionale. Masson et Cie éditeurs, Paris. 411pp.

* Brady S.G., Schultz T.R., Fisher B.L., Ward P.S. (2006) Evaluating alternative hypotheses for the early evolution and diversification of ants. PNAS 103: 18172-18177.

* Brunner E, Kroiss J, Trindl A, Heinze J (2011) Queen pheromones in *Temnothorax* ants: control or honest signal? BMC Evolutionary Biology 11:55. http://www.biomedcentral.com/1471-2148/11/55

Buschinger A (1966) *Leptothorax* (*Mychothorax*) *muscorum* Nylander und *Leptothorax* (*M.) gredleri* Mayr zwei gute Arten. Insect Soc 13: 165-172.

Cagniant H, Espadaler X (1997). Les *Leptothorax*, *Epimyrma* et *Chalepoxenus* du Maroc (Hymenoptera: Formicidae). Clé et catalogue des espèces. Annales de la Société Entomologique de France (NS) 33: 259-284

Espadaler X (1996) Diagnosis preliminar de siete especies nuevas de hormigas de la Península Ibérica (Hymenoptera: Formicidae). Zapateri 6: 151-153

Espadaler X (1997) Redescription of *Leptothorax schaufussi* (Forel, 1879) (Hymenoptera: Formicidae). Orsis 12:101-107

* Goropashnaya AV, Fedorov VB, Seifert B, Pamilo P (2012) Phylogenetic relationships of palaearctic *Formica* species (Hymenoptera, Formicidae) based on mitochondrial cytochrome b sequences. PLoS ONE 7(7): e41697. doi:10.1371/journal.pone.0041697

* Hasegawa E., Tinaut A., Ruano F. (2002) Molecular phylogeny of two slave-making ants: *Rossomyrmex* and *Polyergus* (Hymenoptera: Formicidae). Ann.Zool.Fennici 39: 267-271.

Janda M., Folkova D., Zrzavy J. (2004) Phylogeny of *Lasius* ants based on mitochondrial DNA and morphology, and the evolution of social parasitism in the Lasiini (Hymenoptera: Formicidae). Molecular Phylogenetics and Evolution 33: 595-614.

* Jansen G, Savolainen R, Vepsäläinen K (2009) DNA barcoding as a heuristic tool for classifying undescribed Nearctic *Myrmica* ants (Hymenoptera: Formicidae). Zoologica Scripta 38: 527-536.

* Jowers M.J., Amor F., Ortega P., Lenoir A., Boulay R.R., Cerdá X., Galarza J.A. (2014) Recent speciation and secondary contact in endemic ants. Molecular Ecology 23: 2529-2542.

* Knaden M., Tinaut A., Stökl J., Cerdá X., Wehner R. (2012) Molecular phylogeny of the desert ant genus *Cataglyphis* (Hymenoptera: Formicidae). Myrmecol. News 16: 123-132.

* Machac A, Janda M, Dunn RR, Sanders NJ (2011) Elevational gradients in phylogenetic structure of ant communities reveal the interplay of biotic and abiotic constraints on species density. Ecography 34: 364-371.

* Maruyama M, Steiner FM, Stauffer C, Akino T, Crozier RH, Schlick-Steiner BC (2008) A DNA and morphology based phylogenetic framework of the ant genus *Lasius* with hypotheses for the evolution of social parasitism and fungiculture. BMC Evolutionary Biology 8:237. doi:10.1186/1471-2148-8-237.

* Moreau CS, Bell CD, Vila R, Archibald SB, Pierce NE (2006) Phylogeny of the ants: diversification in the age of angiosperms. Science 312:101-104.

* Moreau C.S., Bell C.D. (2013) Testing the museum versus cradle tropical biological diversity hypothesis: phylogeny, diversification, and ancestral biogeographic range evolution of the ants. Evolution 67: 2240-2257.

* Muñoz-López M., Palomeque T., Carrillo J.A., Pons J., Tinaut A., Lorite P. (2012) A new taxonomic status for *Iberoformica* (Hymenoptera, Formicidae) based on the use of molecular markers. J Zool Syst Evol Res 50: 30-37.

* Oettler J, Suefuji M, Heinze J (2010) The evolution of alternative reproductive tactics in *Cardiocondyla* male ants. Evolution 64: 3310-3317

Radchenko A.G., Elmes G.W. (2004) Taxonomic notes on the *scabrinodis*-group of *Myrmica* species (Hymenoptera: Formicidae) living in eastern Europe and western Asia, with a description of a new species from Tien Shan. Proc.Russian Entomol. Soc. St. Petersburg 75: 222-233.

Reyes JL, Espadaler X, Rodríguez A (1987) Descripción de *Goniomma baeticum* nov. sp. (Hym., Formicidae). Eos 63: 269-276

Rigato F (2011) Contributions to the taxonomy of West European and North African *Stenamma* of the *westwoodii* species-group. (Hymenoptera Formicidae). Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 37: 1-56.

Sanetra M, Güsten R, Schulz A (1999) On the taxonomy and distribution of the Italian *Tetramorium* species and their social parasites (Hymenoptera Formicidae). Memorie della Società Entomologica Italiana 77: 317-357.

* Sauer C., Stackebrandt E., Gadau J., Hölldobler B., Gross R. (2000) Systematic relationships and cospeciation of bacterial endosymbionts and their carpenter ant host species: proposal of the new taxon *Candidatus Blochmannia* gen. nov. Intern.J.Syst.Evol.Microb. 50: 1877-1886.

* Schlick-Steiner BC, Steiner FM, Moder K, Seifert B, Sanetra M, Dyreson E, Stauffer

C, Christian E (2006) A multidisciplinary approach reveals cryptic diversity in western Palearctic *Tetramorium* ants (Hymenoptera: Formicidae). Molecular Phylogenetics and Evolution 40: 259-273.

* Schlick-Steiner B.C., Steiner F.M., Konrad H., Markó B., Csösz S., Heller G., Ferencz B., Sipos B., Christian E., Stuffer C. (2006) More than one species of *Messor* harvester ants (Hymenoptyera: Formicidae) in Central Europe. Eur. J. Entomol. 103: 469-476.

* Schmidt C.A. (2013) Molecular phylogenetics of ponerine ants (Hymenoptera: Formicidae: Ponerinae). Zootaxa 3647: 201-250..

Seifert B (1992) A taxonomic revision of the Palaearctic members of ant subgenus *Lasius* s.str. (Hymenoptera: Formicidae). Abh. Ber. Naturkundemus. Görlitz 66: 1-67.

Seifert, B. (2000) *Myrmica lonae* Finzi, 1926 – a species separate from *Myrmica sabuleti* Meinert, 1861 (Hymenoptera: Formicidae). Abh. Ber. Naturkundemus. Görlitz 72, 195–205.

Seifert B, Schlick-Steiner BC, Steiner FM (2009) *Myrmica constricta* Karavajev, 1934 - a cryptic species of *Myrmica hellenica* Finzi, 1926 (Hymenoptera: Formicidae). Soil Organisms 81: 53-76

Seifert B, Schultz R (2009) A taxonomic revision of the *Formica rufibarbis* Fabricius, 1793 group (Hymenoptera: Formicidae). Myrmecological News 12: 255-272.

Tinaut A (1991) [1990]. Situación taxonómica del género *Cataglyphis* Förster, 1850 en la Península Ibérica. III. El grupo de *C. velox* Santschi, 1929 y descripción de *Cataglyphis humeya* sp. n. (Hymenoptera, Formicidae). EOS 66: 215-227

Tinaut A (1993) *Cataglyphis floricola* nov. sp. new species for the genus *Cataglyphi*s Förster, 1850 (Hymenoptera, Formicidae) in the Iberian Peninsula. Mitt Schweiz Entomol Ges 66: 123-134

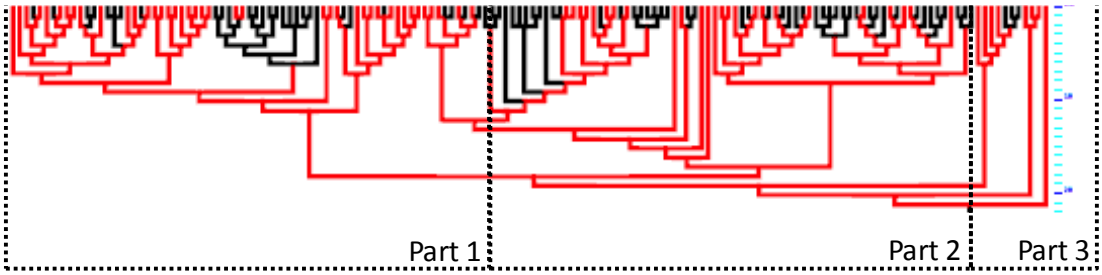
Tinaut A, Ruano F, Hidalgo J, Ballesta M (1994) Mirmecocenosis del sistema de dunas del Paraje Natural Punta Entinas-El Sabinar (Almería) (Hymenoptera Formicidae) Aspectos taxonómicos functionales y biogeográficos. Graellsia 50: 71-84

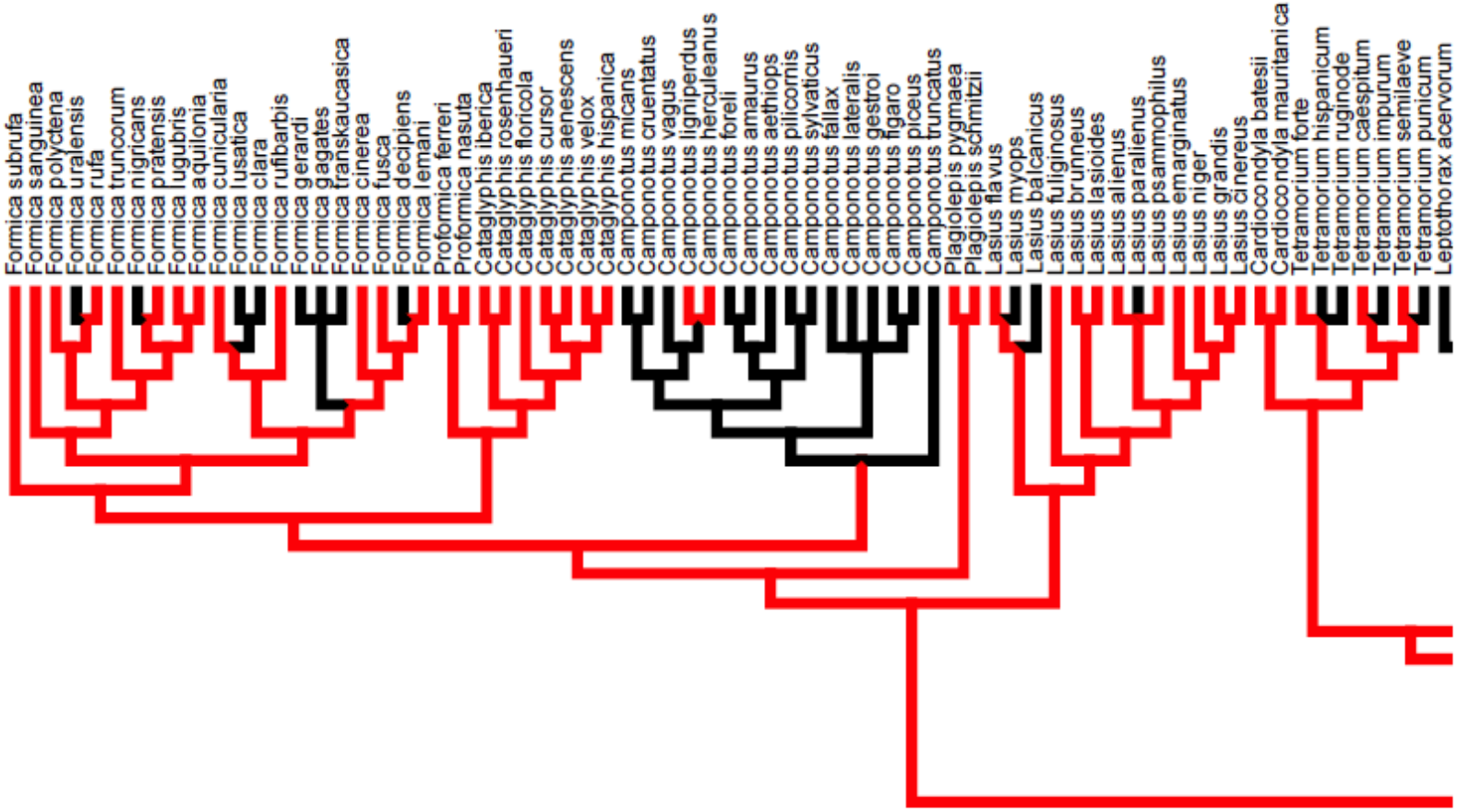
Ward PS (2007) Phylogeny, classification, and species-level taxonomy of ants (Hymenoptera: Formicidae). Zootaxa 1668: 549-563

Phylogenetic signals present in ant functional traits (quantified using Pagel's λ), first using all the ant species included in this study (Europe) and then using the subsets of species found in each biogeographic region (*, p<0.05; **, p<0.01; and ***, p<0.001).

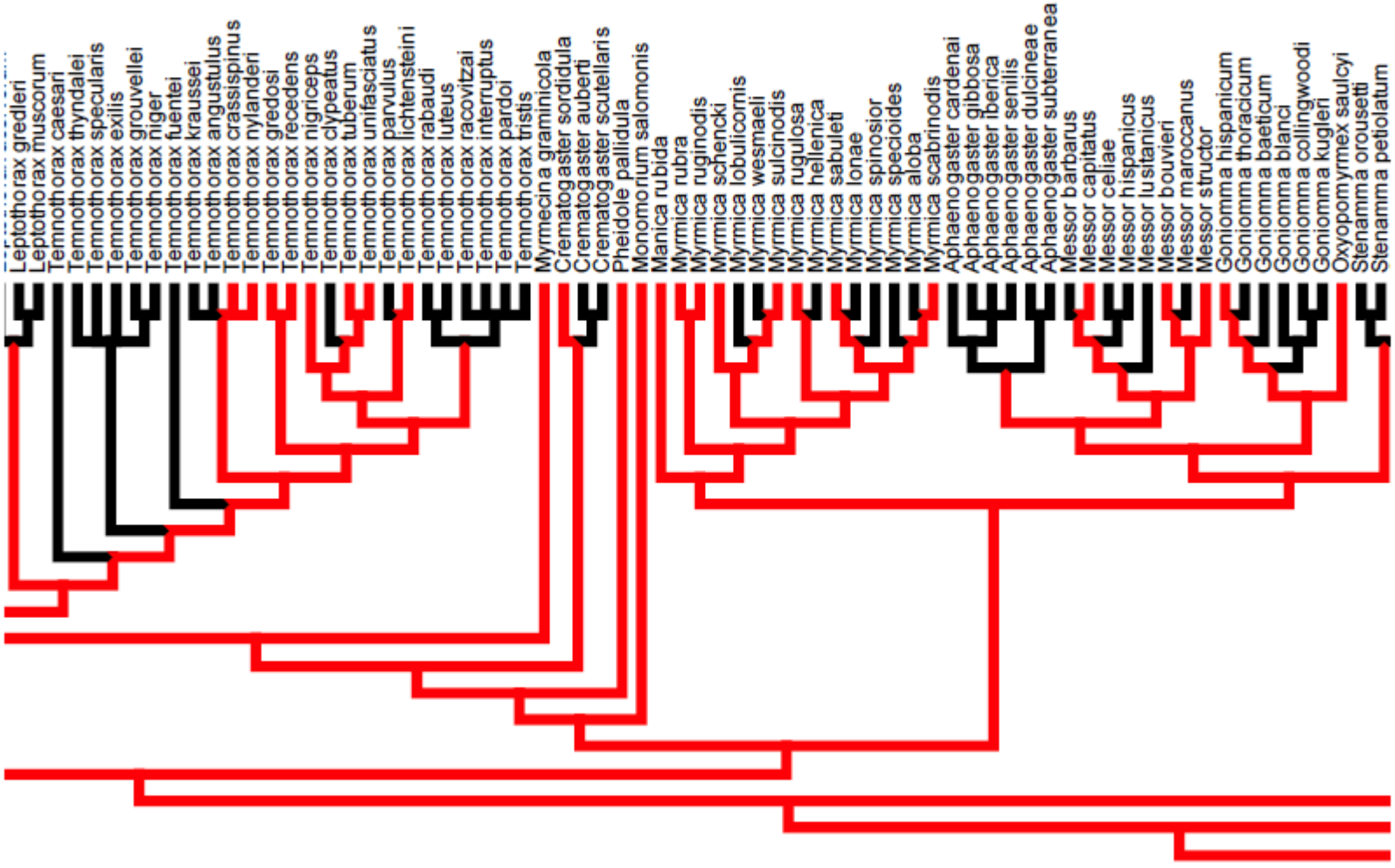
Trait	Europe	Mediterranean	Continental	Atlantic	Alpine	Boreal
Worker size	**0.97*** **	**0.99*** **	**0.82*** **	**0.88*** **	**0.97*** **	**0.97*** **
Worker polymorphism	**0.92*** **	**0.96*** **	**0.35*** **	**0.43*** **	**0.36***	**0.69*** **
Colony size	**0.99*** **	**0.99*** **	**0.95*** **	**0.98*** **	0.52	**0.90*** **
% Seeds in diet	**1.00*** **	**1.00*** **	**1.00*** **	**1.00*** **	**1.00*** **	**1.00*** **
% Insects in diet	**0.99*** **	**0.99*** **	**0.93*** **	**0.98*** **	**1.00*** **	**1.00*** **
% Liquid Foods in diet	**0.99*** **	**0.98*** **	**0.95*** **	**0.98*** **	**1.00*** **	**1.00*** **
Independent Colony Foundation	**0.91*** **	**0.95*** **	**0.99*** **	**0.97*** **	**0.92*** **	**0.88*** **
Polydomy	**0.82*** **	**0.91*** **	**0.81*** **	**0.79*** **	**0.66*** **	**0.56*** **
Polygyny	**0.89*** **	**0.91*** **	**0.71*** **	**0.96*** **	**1.00*** **	**0.94*** **
Strictly diurnal	**0.89*** **	**0.92*** **	**0.71*** **	**0.61*** **	**1.00*** **	**0.99*** **
Dominant	**0.98*** **	**0.99*** **	**0.85*** **	**0.92*** **	**0.74*** **	**0.82*** **
Foraging strategy	**1.00*** **	**1.00*** **	**1.00*** **	**1.00*** **	**0.94*** **	**1.00****

Ultrametricized ant phylogeny used in this study. It has been reconstructed from different sources in the literature (see above). Red branches indicate a phylogenetic position of taxa obtained from molecular data. Black branches indicate a position obtained from morphology-taxonomic studies.

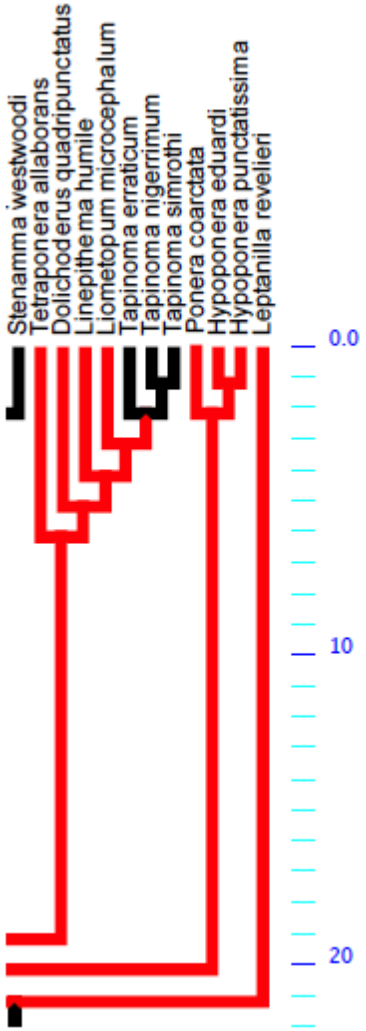



Formica subrufa
Formica sanguinea
Formica polyctena
Formica uralensis
Formica rufa
Formica truncorum
Formica nigricans
Formica pratensis
Formica lugubris
Formica aquilonia
Formica cunicularia
Formica lusatica
Formica clara
Formica rufibarbis
Formica gerardi
Formica gagates
Formica transkaucasica
Formica cinerea
Formica fusca
Formica decipiens
Formica lemani
Proformica ferreri
Proformica nasuta
Cataglyphis iberica
Cataglyphis rosenhaueri
Cataglyphis floricola
Cataglyphis cursor
Cataglyphis aenescens
Cataglyphis velox
Cataglyphis hispanica
Camponotus micans
Camponotus cruentatus
Camponotus vagus
Camponotus ligniperdus
Camponotus herculeanus
Camponotus foreli
Camponotus amaurus
Camponotus aethiops
Camponotus piliconis
Camponotus sylvaticus
Camponotus fallax
Camponotus lateralis
Camponotus gestroi
Camponotus figaro
Camponotus piceus
Camponotus truncatus
Plagiolepis pygmaea
Plagiolepis schmitzii
Lasius flavus
Lasius myops
Lasius balcanicus
Lasius fuliginosus
Lasius brunneus
Lasius lasioides
Lasius alienus
Lasius paralienus
Lasius psammophilus
Lasius emarginatus
Lasius niger
Lasius grandis
Lasius cinereus
Cardiocondyla batesii
Cardiocondyla mauritanica
Tetramorium forte
Tetramorium hispanicum
Tetramorium ruginode
Tetramorium caespitum
Tetramorium impurum
Tetramorium semilaeve
Tetramorium punicum
Leptothorax acervorum

Part 1/3


Leptothorax gredleri
Leptothorax muscorum
Temnothorax caesari
Temnothorax thyndalei
Temnothorax specularis
Temnothorax exilis
Temnothorax grouvellei
Temnothorax niger
Temnothorax fuentei
Temnothorax kraussei
Temnothorax angustulus
Temnothorax crassispinus
Temnothorax nylanderi
Temnothorax gredosi
Temnothorax recedens
Temnothorax nigriceps
Temnothorax clypeatus
Temnothorax tuberum
Temnothorax unifasciatus
Temnothorax parvulus
Temnothorax lichtensteini
Temnothorax rabaudi
Temnothorax luteus
Temnothorax racovitzai
Temnothorax interruptus
Temnothorax pardoi
Temnothorax tristis
Myrmecina graminicola
Crematogaster sordidula
Crematogaster auberti
Crematogaster scutellaris
Pheidole pallidula
Monomorium salomonis
Manica rubida
Myrmica rubra
Myrmica ruginodis
Myrmica schencki
Myrmica lobulicornis
Myrmica wesmaeli
Myrmica sulcinodis
Myrmica rugulosa
Myrmica hellenica
Myrmica sabuleti
Myrmica lonae
Myrmica spinosior
Myrmica specioides
Myrmica aloba
Myrmica scabrinodis
Aphaenogaster cardenai
Aphaenogaster gibbosa
Aphaenogaster iberica
Aphaenogaster senilis
Aphaenogaster dulcineae
Aphaenogaster subterranea
Messor barbarus
Messor capitatus
Messor celiae
Messor hispanicus
Messor lusitanicus
Messor bouvieri
Messor maroccanus
Messor structor
Goniomma hispanicum
Goniomma thoracicum
Goniomma baeticum
Goniomma blanci
Goniomma collingwoodi
Goniomma kugleri
Oxyopomyrmex saulcyi
Stenamma orousetti
Stenamma petiolatum

Part 2/3


Stenamma westwoodi
Tetraponera allaborans
Dolichoderus quadripunctatus
Linepithema humile
Liometopum microcephalum
Tapinoma erraticum
Tapinoma nigerrimum
Tapinoma simrothi
Ponera coarctata
Hypoponera eduardi
Hypoponera punctatissima
Leptanilla revelieri
0.0
10
20

Part 3/3

Appendix 4. Main characteristics of the five biogeographic regions to which the communities included in this study were assigned.

Based on the information obtained in the different documents available in the website of the European Environment Agency (http://www.eea.europa.eu/), we describe the main characteristics of the five biogeographic regions of Europe included in this study.

(i) Mediterranean region. The region covers ca 11 % of Europe's territory and stretches over more than 4 000 km from Lisbon in the west (Portugal) to Adana in the east (Southern Turkey). The climate is warm with hot summers and mild winters. Temperatures are generally highest in the east, but there are periods during the year with temperatures over 30°C occur in all parts of the region. Average annual rainfall range varies between 500 and 1100 mm/year in many regions, but can be as low as 350 or even 100 mm. At the local scale, the Mediterranean region is known for pronounced climatic differences over very short distances because of factors such as slope, exposition, distance from sea, steepness and parent rock type. Arid and desert conditions are increasing and water will become more and more scarce during the 21th century. Soils are low in humus, and the erosion risk is great in most areas.

(ii) Continental region. It is the second largest biogeographic region in Europe, nearly as big as the Boreal region. The Continental region extends in a central east-west band over most of Europe. A relatively narrow fringe of land separates it from the Atlantic Ocean in the west; in the east it reaches as far as the border of Asia, just south of the Ural Mountains. It reaches Denmark and Sweden in the north, Italy and the Balkan Peninsula in the south. The climate in the region can be defined as truly continental with warm summers and cold winters, especially in the central and eastern parts where there are strong contrasts in seasonal temperatures, with generally warm summers and cold winters. Rainfall is most abundant during summer. Precipitation in the region varies mainly according to altitude and exposition. Towards the west, these characteristics become less and less marked due to oceanic influences. The soils have naturally high fertility.

(iii) Atlantic region. This region is closely interacting with the bordering northeast Atlantic Ocean and the North Sea and has a very long coastline and islands. It borders both the coldest and the some of the warmest parts of Europe: the Arctic and Scandinavian alpine regions in the north (Norway) and the Mediterranean region in the south (Portugal, Spain and France), but the closest contact is with the temperate western part of the Continental region. The climate is mild and humid. Differences in temperature between summer and winter are small. The eastern limit of the region approximately follows the line where the annual temperature range is 16°C. The whole region has in general a surplus of water, though there are large differences from west to east. Rainfall is very high in the western parts, reaching up to 3000 mm per year on the mountains of Northwest Scotland, while it can be as little as 550 mm per year in lowlands in the eastern parts of the region.

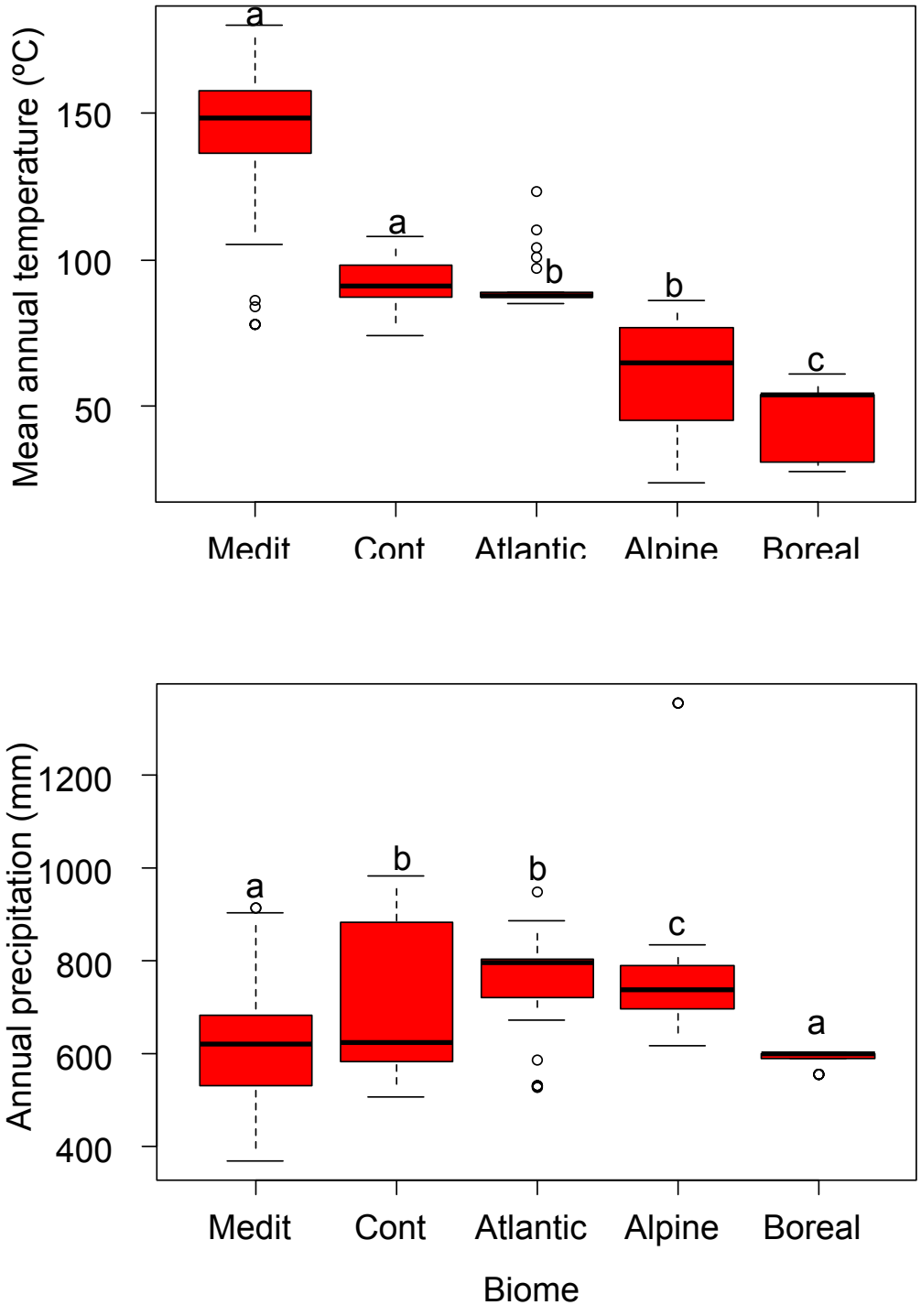
(iv) Alpine region. The Alpine biogeographic region includes some of the oldest and most recent ranges of mountains of the world, from the Mediterranean to western Siberia: the Alps, the Scandes, the Pyrenees, the Carpathians, the Rhodopes, the Urals, the Caucasia and the Dinaric Alps. These mountains areas are vulnerable ecosystems, characterised by low

productivity, slow response rates and isolation. In general this region is characterized by relatively large differences between the average summer and average winter temperatures as well as relatively high amount of precipitation during the year, but the climate of the different ranges included in the region is not homogeneous. Some of the ranges are severely influenced by the Mediterranean climate in the south and with the temperate climate in the north, with annual precipitation between 500 and 1200 mm and mean temperatures in the range 5-10ºC. Other mountain ranges are located in colder areas (mean annual temperature around 0ºC) and have relatively lower precipitation (400 to 1000 mm).

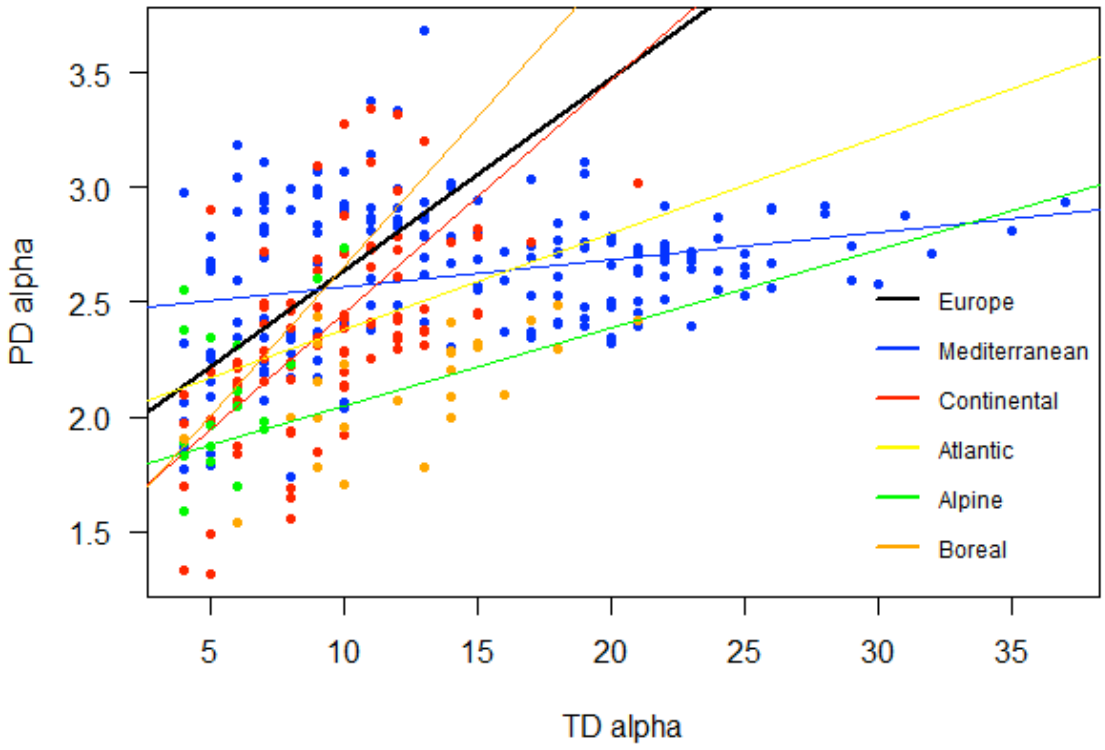
(v) Boreal region. It is the largest biogeographic region of Europe, covering around ¼ of Europe's territory and involves eight countries: south eastern Norway, the majority of Sweden, most of Finland, all Estonia and Latvia and the northern parts of Lithuania and Belarus. Most of the Boreal region lies less 500 m above sea level. The region has a cool-temperate, moist climate, varying from sub-oceanic in the west to sub-continental in the interior and the east. Precipitation varies between 500 and 800 mm per year, with extremes of 300 and 1 200 mm. Average annual temperatures are generally low, but vary much over the region: with monthly mean temperatures varying from + 20 °C in the warmest months of the warmest areas to -15 °C in the coldest months in the coldest areas.

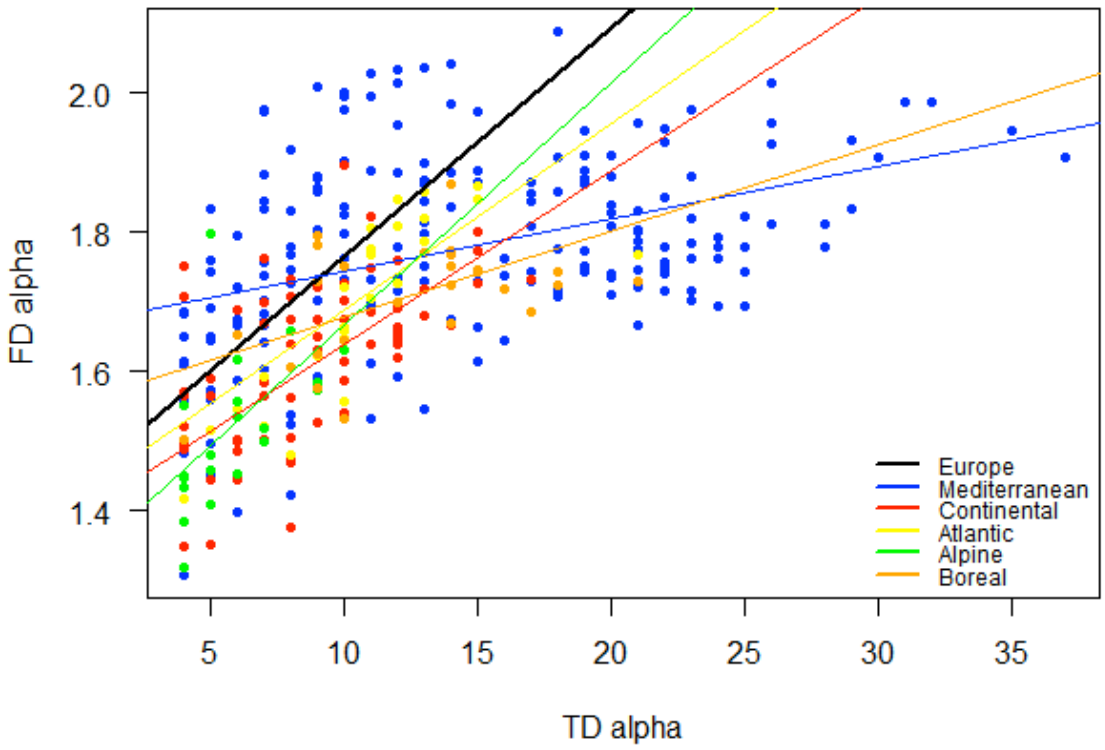
Climate characterization (mean annual temperature and annual precipitation) of these five biogeographic regions according to values of these variables from the study plots provided by the WorldClim database (http://www.worldclim.org/bioclim) is shown in Figure S4.1.

Figure A3. Climate characterization (mean annual temperature – x10 - and annual precipitation) of the study plots included in the five biogeographic regions considered.

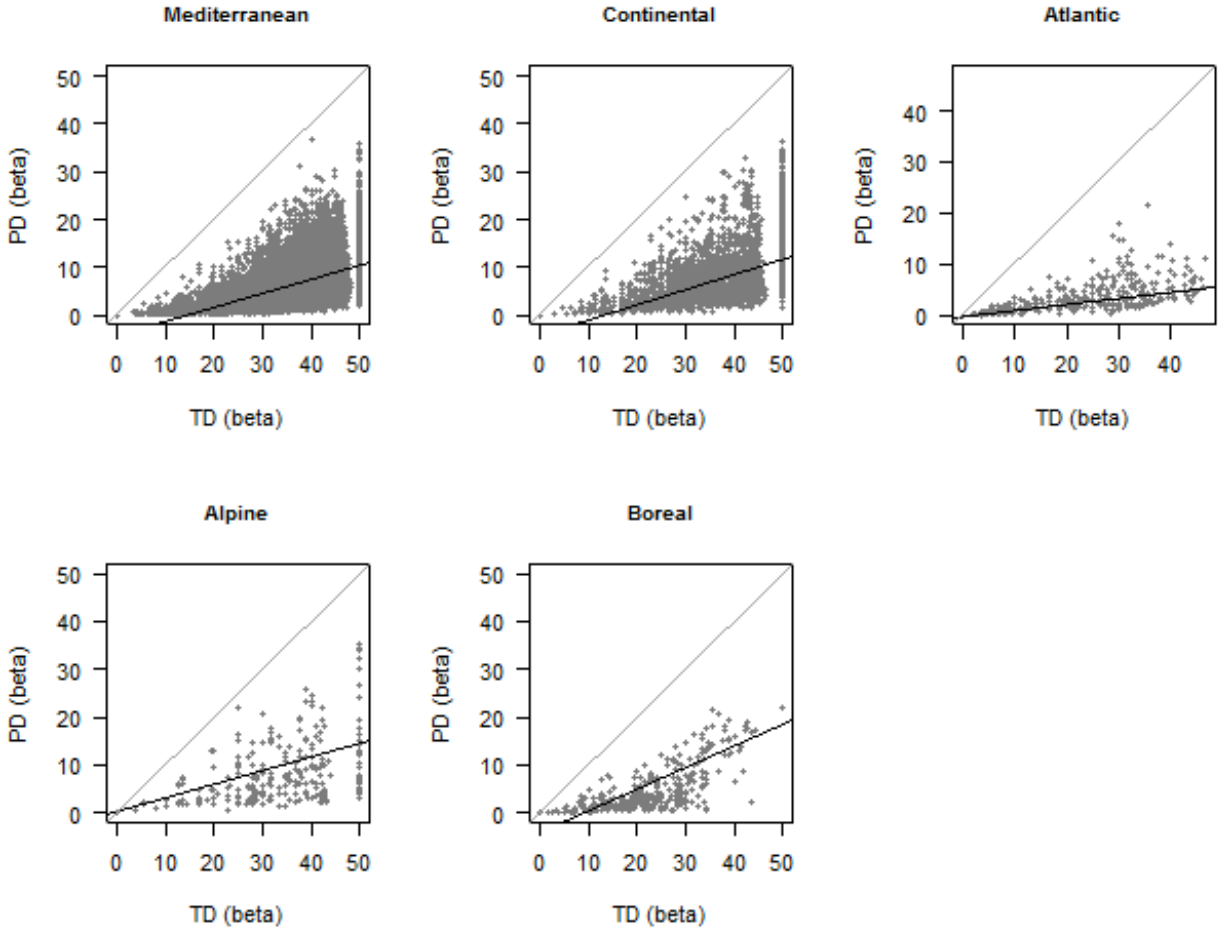


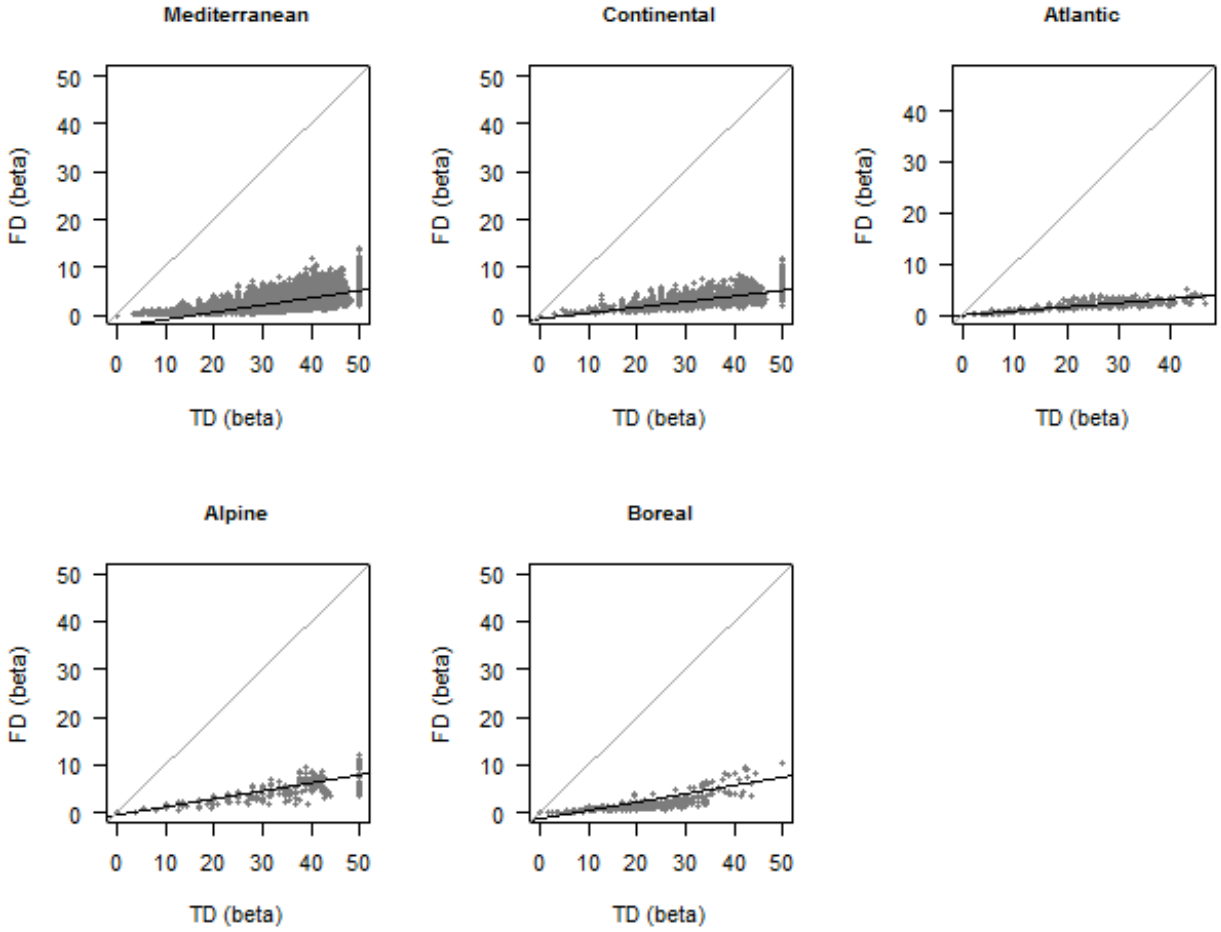
Appendix 5. Relationships between alpha taxonomic diversity and alpha phylogenetic diversity (FD) or alpha functional diversity (PD) in each biogeographic region.

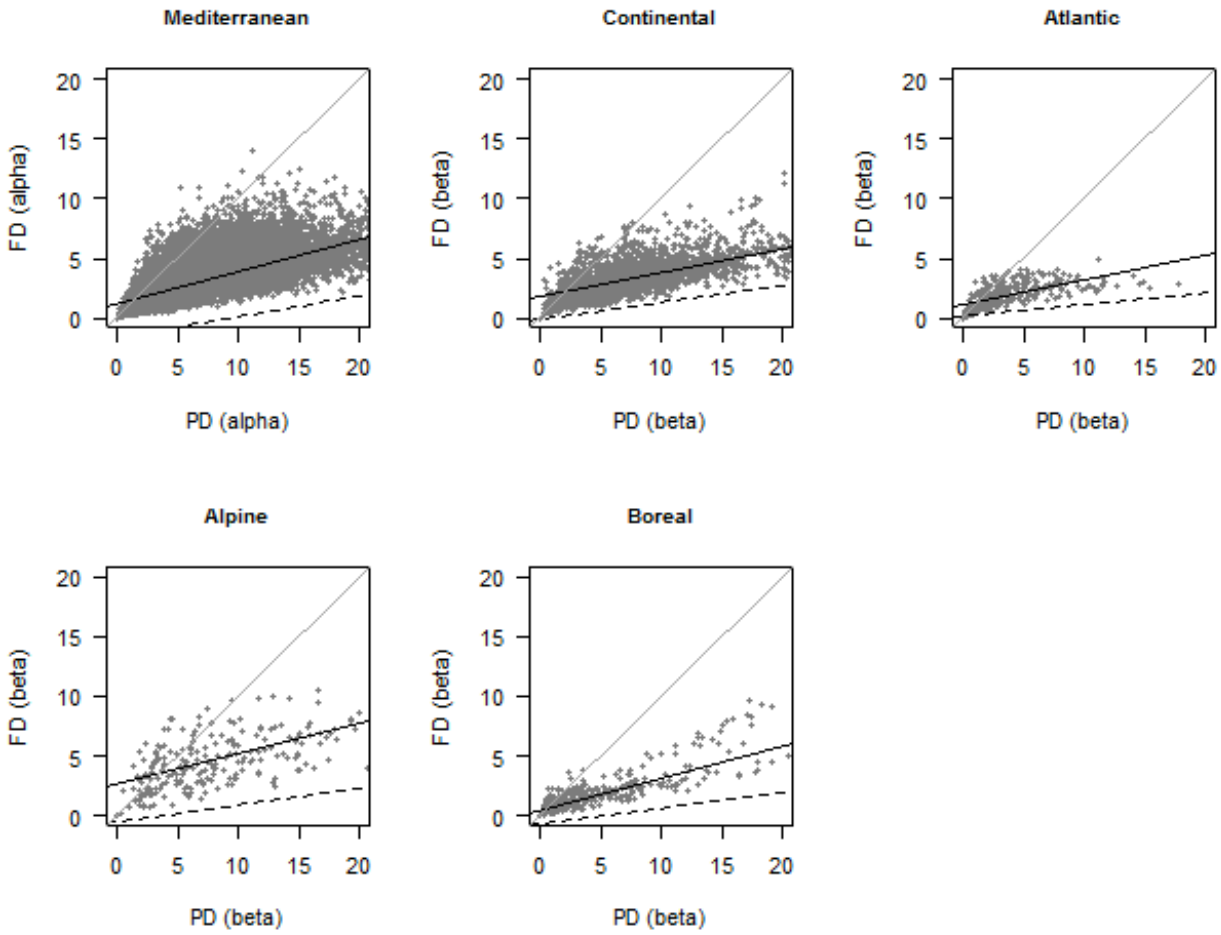



FD alpha
2.0
1.8
1.6
1.4
5
10
15
20
25
30
35
TD alpha
Europe
Mediterranean
Continental
Atlantic
Alpine
Boreal

Appendix 6. Relationships between beta diversity components in each biogeographic region.




Mediterranean
Continental
Atlantic
Alpine
Boreal
FD (beta)
TD (beta)
0
10
20
30
40
50


Mediterranean
Continental
Atlantic
Alpine
Boreal
FD (alpha)
FD (beta)
PD (alpha)
PD (beta)
0
5
10
15
20