

Supporting Information

The non-random assembly of functional motifs in plant-pollinator networks worldwide

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TABLES

Table S1 List of plant-pollinator network studies.

Table S2 List of the plant species used in this study.

Table S3 Type of plant traits used in this study.

FIGURES

Figure S1 Over and under-estimated motif frequencies.

Figure S2 Over and under-estimated functional groups on motif positions.

Figure S3 Plant trait composition of functional groups.

Figure S4 Plant dendrogram with functional groups.

Table S1. List of studies ordered by author with the year of publication, number of contributed networks and digital object identifier

First author	Year	Number of networks	Country	DOI
Arroyo-Correa	2019	3	New Zealand	https://doi.org/10.1111/1365-2745.13332
Bartomeus	2008	6	Spain	https://doi.org/10.1007/s00442-007-0946-1
Bartomeus	2015	16	Spain	https://github.com/ibartomeus/BeeFunData
Bundgaard	2003	1	Denmark	Unpublished, Master thesis
Burkle	2013	1	United States	https://doi.org/10.1126/science.1232728
Dicks	2002	2	England	https://doi.org/10.1046/j.0021-8790.2001.00572.x
Dupont	2003	3	Denmark	https://doi.org/10.1111/j.1365-2656.2008.01501.x
Elberling	1999	1	Sweden	https://doi.org/10.1111/j.1600-0587.1999.tb00507.x
Fang	2008	1	China	https://doi.org/10.1111/1749-4877.12190
Inouye	1988	1	United States	https://doi.org/10.1111/j.1442-9993.1988.tb00968.x
Kaiser-Bunbury	2017	8	Seychelles	https://doi.org/10.1038/nature21071
Kaiser-Bunbury	2011	6	Seychelles	https://doi.org/10.1111/j.1365-2745.2010.01732.x
Kaiser-Bunbury	2010	2	Mauritius	https://doi.org/10.1016/j.ppees.2009.04.001
Lundgren	2005	1	Denmark (Greenland)	https://doi.org/10.1657/1523-0430(2005)037[0514:TDAHCW]2.0.CO;2
Olesen	2002	2	Mauritius and Portugal (Azores)	https://doi.org/10.1046/j.1472-4642.2002.00148.x
Peralta	2006	4	Argentina	https://doi.org/10.1111/ele.13510
Small	1976	1	Japan	/13960/t4km08d21
Souza	2017	1	Brazil	https://doi.org/10.1111/1365-2745.12978

Table S2. List of the 503 plant species used in this study.

List of plant species		
<i>Acantholippia seriphioides</i>	<i>Erica umbellata</i>	<i>Peponidium carinatum</i>
<i>Achillea millefolium</i>	<i>Erigenia bulbosa</i>	<i>Pereskia sacharosa</i>
<i>Achillea wilsoniana</i>	<i>Erophaca baetica</i>	<i>Persicaria runcinata</i>
<i>Aciphylla glacialis</i>	<i>Eryngium campestre</i>	<i>Persicaria vivipara</i>
<i>Aciphylla simplicifolia</i>	<i>Erythronium albidum</i>	<i>Phlomis atropurpurea</i>
<i>Acrothamnus montanus</i>	<i>Erythrospermum monticolum</i>	<i>Phlomis purpurea</i>
<i>Actaea yunnanensis</i>	<i>Erythroxyllum macrocarpum</i>	<i>Phlomis tatsienensis</i>
<i>Adenophora capillaris</i>	<i>Erythroxyllum sechellarum</i>	<i>Phlox divaricata</i>
<i>Adenophora jasionifolia</i>	<i>Eugenia kanakana</i>	<i>Phoenicophorium borsigianum</i>
<i>Adenophora khasiana</i>	<i>Eugenia orbiculata</i>	<i>Phyllanthus phillyreifolius</i>
<i>Aeschynomene mollicula</i>	<i>Euphorbia pyrifolia</i>	<i>Picris hieracioides</i>
<i>Agarista salicifolia</i>	<i>Euphorbia segetalis</i>	<i>Pilosella officinarum</i>
<i>Agrimonia pilosa</i>	<i>Euphrasia collina</i>	<i>Pimelea ligustrina</i>
<i>Ajuga forrestii</i>	<i>Euphrasia regelii</i>	<i>Pinguicula alpina</i>
<i>Allium ampeloprasum</i>	<i>Excoecaria benthamiana</i>	<i>Pittosporum senacia</i>
<i>Allium atrosanguineum</i>	<i>Faujasiaopsis flexuosa</i>	<i>Plantago lanceolata</i>
<i>Allium cyathophorum</i>	<i>Filipendula ulmaria</i>	<i>Pleurospermum davidii</i>
<i>Allium wallichii</i>	<i>Flagellaria indica</i>	<i>Pleurostylia leucocarpa</i>
<i>Aloysia gratissima</i>	<i>Freesia refracta</i>	<i>Polemonium reptans</i>
<i>Alstonia macrophylla</i>	<i>Gaertnera petrinensis</i>	<i>Polyscias mauritiana</i>
<i>Anacamptis morio</i>	<i>Gaertnera psychotrioides</i>	<i>Portulaca fluvialis</i>
<i>Anaphalioides alpinum</i>	<i>Gaertnera rotundifolia</i>	<i>Potentilla crantzii</i>
<i>Anaphalis nepalensis</i>	<i>Galactites tomentosus</i>	<i>Potentilla erecta</i>
<i>Anchusa azurea</i>	<i>Galeopsis bifida</i>	<i>Potentilla fallens</i>
<i>Andromeda glaucophylla</i>	<i>Galium saxatile</i>	<i>Potentilla griffithii</i>
<i>Andryala integrifolia</i>	<i>Galium verum</i>	<i>Potentilla lancinata</i>
<i>Anemone rivularis</i>	<i>Gastonia crassa</i>	<i>Potentilla rubricaulis</i>
<i>Anemonella thalictroides</i>	<i>Gaylussacia baccata</i>	<i>Premna serratifolia</i>
<i>Angelica archangelica</i>	<i>Geniostoma borbonicum</i>	<i>Primula poissonii</i>
<i>Anthriscus sylvestris</i>	<i>Genista anglica</i>	<i>Primula secundiflora</i>
<i>Antidesma madagascariense</i>	<i>Genista hirsuta</i>	<i>Primula veris</i>
<i>Antirhea borbonica</i>	<i>Genista pilosa</i>	<i>Prosopis flexuosa</i>
<i>Aphloia theiformis</i>	<i>Gentiana chungtienensis</i>	<i>Prosopis rubriflora</i>
<i>Arabis alpina</i>	<i>Gentiana crassicaulis</i>	<i>Prostanthera cuneata</i>
<i>Arachis microsperma</i>	<i>Gentianella diemensis</i>	<i>Prunella vulgaris</i>
<i>Arctium lappa</i>	<i>Geranium delavayi</i>	<i>Pseudognaphalium affine</i>
<i>Arctotheca calendula</i>	<i>Geranium maculatum</i>	<i>Psiadia terebinthina</i>
<i>Arenaria yunnanensis</i>	<i>Glionnetia sericea</i>	<i>Psidium cattleyanum</i>
<i>Argusia argentea</i>	<i>Gomphrena celosioides</i>	<i>Psychotria pervillei</i>
<i>Armeria velutina</i>	<i>Gomphrena elegans</i>	<i>Psychotria terniflora</i>
<i>Arnica montana</i>	<i>Grangeria borbonica</i>	<i>Pterocephalus hookeri</i>
<i>Aronia melanocarpa</i>	<i>Halenia elliptica</i>	<i>Pyrola grandiflora</i>
<i>Asphodelus fistulosus</i>	<i>Halimium commutatum</i>	<i>Pyrostria bibracteata</i>
<i>Aster diplostephioides</i>	<i>Halimium halimifolium</i>	<i>Pyrostria fasciculata</i>
<i>Aster oreophilus</i>	<i>Hancea integrifolia</i>	<i>Ranunculus acris</i>
<i>Aster souliei</i>	<i>Harrimanella hypnoides</i>	<i>Ranunculus hispidus</i>
<i>Aster vestitus</i>	<i>Harungana madagascariensis</i>	<i>Reseda luteola</i>

<i>Aster yunnanensis</i>	<i>Helenium donianum</i>	<i>Rhododendron lapponicum</i>
<i>Astragalus alpinus</i>	<i>Helichrysum proteoides</i>	<i>Richea continentis</i>
<i>Astragalus pullus</i>	<i>Helichrysum stoechas</i>	<i>Rosa rubiginosa</i>
<i>Atamisquea emarginata</i>	<i>Herissantia nemoralis</i>	<i>Roscheria melanochaetes</i>
<i>Ayenia tomentosa</i>	<i>Herpetospermum pedunculatum</i>	<i>Rosmarinus officinalis</i>
<i>Azorina vidalii</i>	<i>Heteropterys glabra</i>	<i>Roussea simplex</i>
<i>Badula insularis</i>	<i>Hibiscus tiliaceus</i>	<i>Rubus alceifolius</i>
<i>Badula platyphylla</i>	<i>Hieracium praealtum</i>	<i>Rubus plicatus</i>
<i>Baeckea gunniana</i>	<i>Hieracium umbellatum</i>	<i>Ruellia tweediana</i>
<i>Bakerella hoyifolia</i>	<i>Homalanthus populifolius</i>	<i>Ruta chalepensis</i>
<i>Bartsia alpina</i>	<i>Hydrophyllum appendiculatum</i>	<i>Salix fragilis</i>
<i>Bertiera zaluzania</i>	<i>Hydrophyllum virginianum</i>	<i>Salix lanata</i>
<i>Beta vulgaris</i>	<i>Hypericum perforatum</i>	<i>Salix polaris</i>
<i>Bistorta macrophylla</i>	<i>Hypericum perforatum</i>	<i>Salix repens</i>
<i>Bistorta sinomontana</i>	<i>Hypochaeris radicata</i>	<i>Salix reticulata</i>
<i>Bituminaria bituminosa</i>	<i>Impatiens chungtienensis</i>	<i>Salvia przewalskii</i>
<i>Brassica fruticulosa</i>	<i>Ipomoea macrantha</i>	<i>Sanicula odorata</i>
<i>Buddleja mendozensis</i>	<i>Isostigma hoffmannii</i>	<i>Saussurea wardii</i>
<i>Calendula arvensis</i>	<i>Ixeridium biparum</i>	<i>Saxifraga aizoides</i>
<i>Calluna vulgaris</i>	<i>Ixora parviflora</i>	<i>Saxifraga oppositifolia</i>
<i>Calophyllum eputamen</i>	<i>Ixora pudica</i>	<i>Scabiosa atropurpurea</i>
<i>Calopogon tuberosus</i>	<i>Juncus allioides</i>	<i>Scabiosa stellata</i>
<i>Camassia scilloides</i>	<i>Kalmia angustifolia</i>	<i>Scaevola taccada</i>
<i>Campanula giesekiana</i>	<i>Kalmia polifolia</i>	<i>Schinus fasciculata</i>
<i>Campanula rotundifolia</i>	<i>Kunzea muelleri</i>	<i>Scoparia montevidensis</i>
<i>Camptosperma seychellarum</i>	<i>Labourdonnaisia calophylloides</i>	<i>Scorzonera humilis</i>
<i>Camptosema paraguariense</i>	<i>Larrea divaricata</i>	<i>Sedum roseum</i>
<i>Canthium bibracteatum</i>	<i>Larrea nitida</i>	<i>Sedum sediforme</i>
<i>Cardamine concatenata</i>	<i>Lathyrus clymenum</i>	<i>Senecio lautus</i>
<i>Carduus crispus</i>	<i>Lathyrus pratensis</i>	<i>Senecio pinnatus</i>
<i>Carpobrotus acinaciformis</i>	<i>Lavandula pedunculata</i>	<i>Senna aphylla</i>
<i>Casearia coriacea</i>	<i>Lavandula stoechas</i>	<i>Sida rhombifolia</i>
<i>Cassiope tetragona</i>	<i>Lecanophora heterophylla</i>	<i>Sideroxylon cinereum</i>
<i>Castela coccinea</i>	<i>Ledum palustre</i>	<i>Sideroxylon puberulum</i>
<i>Celmisia asteliifolia</i>	<i>Leontodon saxatilis</i>	<i>Silene acaulis</i>
<i>Celmisia graminifolia</i>	<i>Lepidaploa pseudomuricata</i>	<i>Silene dioica</i>
<i>Centaurea nigra</i>	<i>Leptospermum scoparium</i>	<i>Silene flos-cuculi</i>
<i>Cerastium alpinum</i>	<i>Leucaena leucocephala</i>	<i>Silene gracilicaulis</i>
<i>Cerastium fontanum</i>	<i>Leucanthemum vulgare</i>	<i>Silene suecica</i>
<i>Cereus hildmannianus</i>	<i>Leucochrysum albicans</i>	<i>Silene vulgaris</i>
<i>Chamaedaphne calyculata</i>	<i>Ligularia cymbulifera</i>	<i>Silene yunnanensis</i>
<i>Chamomilla suaveolens</i>	<i>Ligularia dictyoneura</i>	<i>Smilax anceps</i>
<i>Chassalia coriacea</i>	<i>Ligularia lankongensis</i>	<i>Solidago sempervirens</i>
<i>Chassalia petrinensis</i>	<i>Lilium duchartrei</i>	<i>Solidago virgaurea</i>
<i>Chrysobalanus icaco</i>	<i>Linaria viscosa</i>	<i>Sonchus tenerimus</i>
<i>Cinnamomum verum</i>	<i>Linum bienne</i>	<i>Soulamea terminaloides</i>
<i>Cirsium arvense</i>	<i>Lippia alba</i>	<i>Spartium junceum</i>
<i>Cirsium eriophoroides</i>	<i>Lobularia maritima</i>	<i>Spenceria ramalana</i>
<i>Cirsium palustre</i>	<i>Lotus corniculatus</i>	<i>Spermacoce eryngioides</i>
<i>Cirsium pratense</i>	<i>Lotus pedunculatus</i>	<i>Spiraea alba</i>

<i>Cirsium vulgare</i>	<i>Lupinus angustifolius</i>	<i>Stachys sylvatica</i>
<i>Cistus albidus</i>	<i>Lycium chilense</i>	<i>Stachytarpheta indica</i>
<i>Cistus crispus</i>	<i>Lysimachea europaea</i>	<i>Stachytarpheta jamaicensis</i>
<i>Cistus ladanifer</i>	<i>Maianthemum racemosum</i>	<i>Stellaria graminea</i>
<i>Cistus libanotis</i>	<i>Maianthemum trifolium</i>	<i>Stellaria yunnanensis</i>
<i>Cistus monspeliensis</i>	<i>Malva multiflora</i>	<i>Stillingia lineata</i>
<i>Cistus salviifolius</i>	<i>Medusagyne oppositifolia</i>	<i>Stylosanthes hamata</i>
<i>Claoxylon linostachys</i>	<i>Melampyrum pratense</i>	<i>Succisa pratensis</i>
<i>Claytonia virginica</i>	<i>Melicope chapelierii</i>	<i>Suriana maritima</i>
<i>Cleistocactus baumannii</i>	<i>Melicope lunu-ankenda</i>	<i>Swertia forrestii</i>
<i>Clematis akebioides</i>	<i>Memecylon eleagni</i>	<i>Syzygium commersonii</i>
<i>Clematis campestris</i>	<i>Memecylon ovatifolium</i>	<i>Syzygium coriaceum</i>
<i>Cleome guianensis</i>	<i>Menodora decemfida</i>	<i>Syzygium glomeratum</i>
<i>Clinopodium repens</i>	<i>Mentha canadensis</i>	<i>Syzygium jambos</i>
<i>Cnidioscolus urens</i>	<i>Mertensia virginica</i>	<i>Syzygium mauritianum</i>
<i>Coccoloba guaranitica</i>	<i>Microseris lanceolata</i>	<i>Syzygium petrinense</i>
<i>Codonopsis convolvulacea</i>	<i>Microtea scabrida</i>	<i>Syzygium venosum</i>
<i>Coffea macrocarpa</i>	<i>Microula sikkimensis</i>	<i>Syzygium wrightii</i>
<i>Coffea mauritiana</i>	<i>Mimosa hexandra</i>	<i>Tabernaemontana persicarifolia</i>
<i>Colea seychellarum</i>	<i>Mimosa sensibilis</i>	<i>Talinum fruticosum</i>
<i>Condalia microphylla</i>	<i>Mimulus moschatus</i>	<i>Tambourissa peltata</i>
<i>Convolvulus althaeoides</i>	<i>Mimusops erythroxyton</i>	<i>Taraxacum campylodes</i>
<i>Convolvulus arvensis</i>	<i>Mimusops sechellarum</i>	<i>Teucrium fruticans</i>
<i>Corokia cotoneaster</i>	<i>Molinaea arborea</i>	<i>Thalictrum delavayi</i>
<i>Craterispermum microdon</i>	<i>Molinaea macrantha</i>	<i>Thalictrum rostellatum</i>
<i>Crepis capillaris</i>	<i>Mollugo verticillata</i>	<i>Thapsia villosa</i>
<i>Crithmum maritimum</i>	<i>Monarda bradburiana</i>	<i>Thespesia populnea</i>
<i>Croton fothergillifolius</i>	<i>Morinda citrifolia</i>	<i>Thymelaea hirsuta</i>
<i>Croton grangerioides</i>	<i>Muehlenbeckia axillaris</i>	<i>Thymus mastichina</i>
<i>Cuphea thymoides</i>	<i>Muehlenbeckia complexa</i>	<i>Tibetia himalaica</i>
<i>Cyananthus delavayi</i>	<i>Murdannia nudiflora</i>	<i>Tillandsia didisticha</i>
<i>Cynoglossum amabile</i>	<i>Mycelis muralis</i>	<i>Timonius sechellensis</i>
<i>Daucus carota</i>	<i>Myosotis alpestris</i>	<i>Toddalia asiatica</i>
<i>Deckenia nobilis</i>	<i>Nematolepis ovatifolia</i>	<i>Torilis japonica</i>
<i>Delphinium tricornis</i>	<i>Nemopanthus mucronatus</i>	<i>Tradescantia virginiana</i>
<i>Dianthus armeria</i>	<i>Nepenthes pervillei</i>	<i>Trifolium arvense</i>
<i>Dianthus caryophyllus</i>	<i>Nepeta stewartiana</i>	<i>Trifolium dubium</i>
<i>Diapensia lapponica</i>	<i>Nephrosperma vanhoutteanum</i>	<i>Trifolium pratense</i>
<i>Dicentra cucullaria</i>	<i>Neptunia plena</i>	<i>Trifolium repens</i>
<i>Digitalis purpurea</i>	<i>Northia seychellana</i>	<i>Tripogandra glandulosa</i>
<i>Dillenia ferruginea</i>	<i>Ochna kirkii</i>	<i>Tristemma mauritianum</i>
<i>Dillenia suffruticosa</i>	<i>Ochna mauritiana</i>	<i>Trochetia blackburniana</i>
<i>Diospyros revaughanii</i>	<i>Ocotea laevigata</i>	<i>Trollius europaeus</i>
<i>Diospyros seychellarum</i>	<i>Olea lancea</i>	<i>Trollius vaginatus</i>
<i>Diplotaxis virgata</i>	<i>Olearia bullata</i>	<i>Tuberaria guttata</i>
<i>Dipsacus asperoides</i>	<i>Onosma confertum</i>	<i>Turnera angustifolia</i>
<i>Dipsacus chinensis</i>	<i>Opuntia elatior</i>	<i>Turraea rigida</i>
<i>Dodonaea viscosa</i>	<i>Opuntia stricta</i>	<i>Ulex parviflorus</i>
<i>Doratoxylon apetalum</i>	<i>Opuntia sulphurea</i>	<i>Urospermum picroides</i>
<i>Dorycnium pentaphyllum</i>	<i>Origanum vulgare</i>	<i>Uvularia grandiflora</i>

<i>Dracaena concinna</i>	<i>Orites lancifolius</i>	<i>Vaccinium myrtilloides</i>
<i>Dracaena reflexa</i>	<i>Oxalis violacea</i>	<i>Vaccinium myrtillus</i>
<i>Dryas integrifolia</i>	<i>Oxylobium ellipticum</i>	<i>Vaccinium uliginosum</i>
<i>Dryas octopetala</i>	<i>Ozothamnus leptophyllus</i>	<i>Vaccinium vitis-idaea</i>
<i>Dubyaea bhotanica</i>	<i>Pandanus barkleyi</i>	<i>Verbascum thapsus</i>
<i>Echinopsis candicans</i>	<i>Pandanus rigidifolius</i>	<i>Veronica brachysiphon</i>
<i>Echinopsis rhodotricha</i>	<i>Pandanus wiehei</i>	<i>Vicia cracca</i>
<i>Echium plantagineum</i>	<i>Paragenipa wrightii</i>	<i>Vicia lutea</i>
<i>Echium sabulicola</i>	<i>Paraserianthes serratifolia</i>	<i>Vicia sativa</i>
<i>Eleutherine bulbosa</i>	<i>Parkinsonia praecox</i>	<i>Viola biflora</i>
<i>Embelia angustifolia</i>	<i>Parnassia palustris</i>	<i>Viola pubescens</i>
<i>Empetrum nigrum</i>	<i>Passiflora suberosa</i>	<i>Viola sororia</i>
<i>Enemion biternatum</i>	<i>Pavonia sidifolia</i>	<i>Wahlenbergia albomarginata</i>
<i>Epacris petrophila</i>	<i>Pedicularis cephalantha</i>	<i>Wahlenbergia ceracea</i>
<i>Epilobium angustifolium</i>	<i>Pedicularis densispica</i>	<i>Waltheria indica</i>
<i>Epilobium gunnianum</i>	<i>Pedicularis dichotoma</i>	<i>Warneckea trinervis</i>
<i>Epilobium hirsutum</i>	<i>Pedicularis rex</i>	<i>Wikstroemia indica</i>
<i>Epilobium latifolium</i>	<i>Pedicularis siphonantha</i>	<i>Xylopia lamarckii</i>
<i>Epilobium tibetanum</i>	<i>Pedicularis tricolor</i>	<i>Ziziphus mistol</i>
<i>Erica scoparia</i>	<i>Pemphis acidula</i>	<i>Zuccagnia punctata</i>
<i>Erica tetralix</i>	<i>Pentachondra pumila</i>	

Table S3. Traits used to delimit the different plant functional groups divided in quantitative and categorical traits.

Quantitative traits		Categorical traits	
Type	Traits	Type	Traits
Vegetative	Plant height (m)	Vegetative	Lifepan
Floral	Flower width (mm)	Vegetative	Life form
Floral	Flower length (mm)	Floral	Flower shape
Floral	Inflorescence width (mm)	Floral	Flower symmetry
Floral	Style length (mm)	Reproductive	Autonomous selfing
Floral	Ovules per flower	Reproductive	Compatibility system
Floral	Flowers per plant	Reproductive	Breeding system
Reproductive	Autonomous selfing (fruit set)		

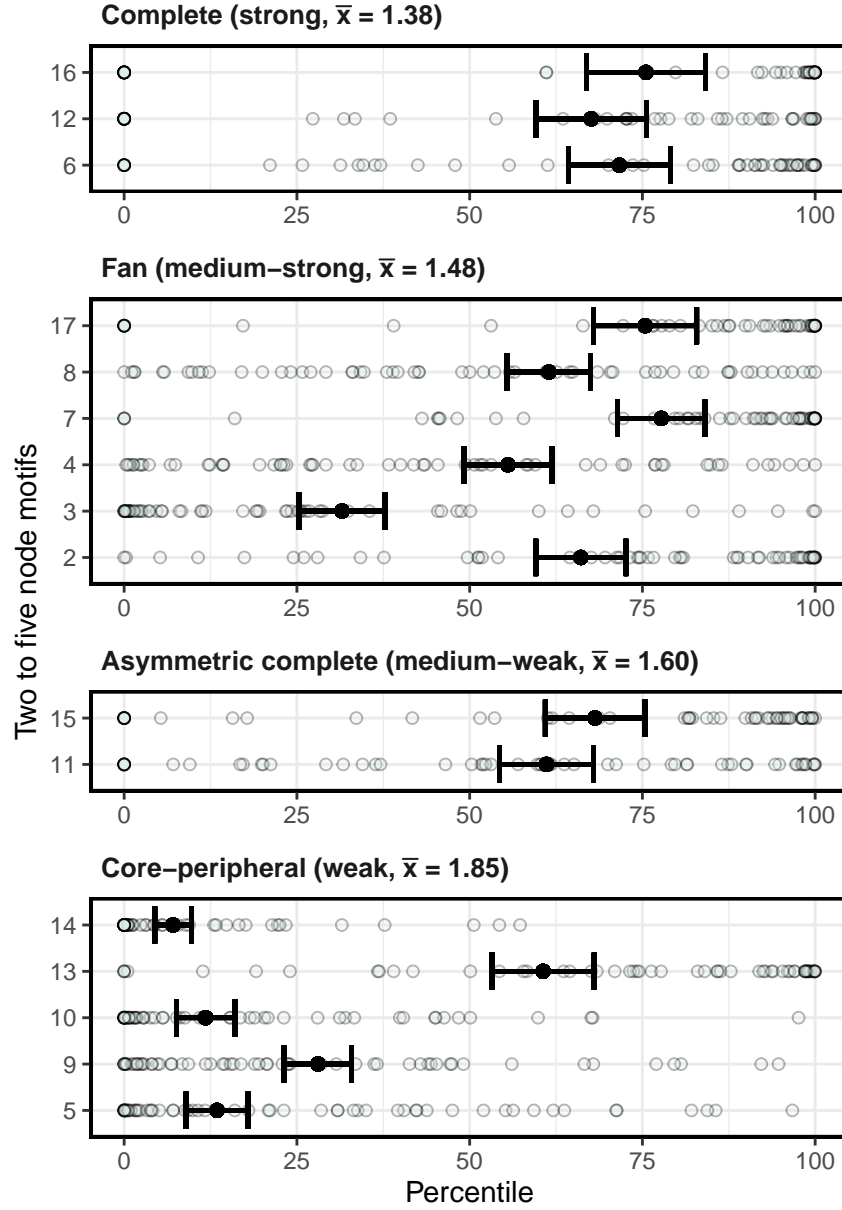


Figure S1. Comparison of motif frequencies between empirical and simulated networks grouped by average path length (plots a, b, c and d) as determined in Simmons et al. (2020) without considering singletons. This is shown with the mean percentage of motif frequencies in empirical networks that were over the motif frequencies of the simulated ones (percentiles). This was done by network (light blue dots) and then averaged for all networks (black dots with error bars that correspond to the standard deviation).

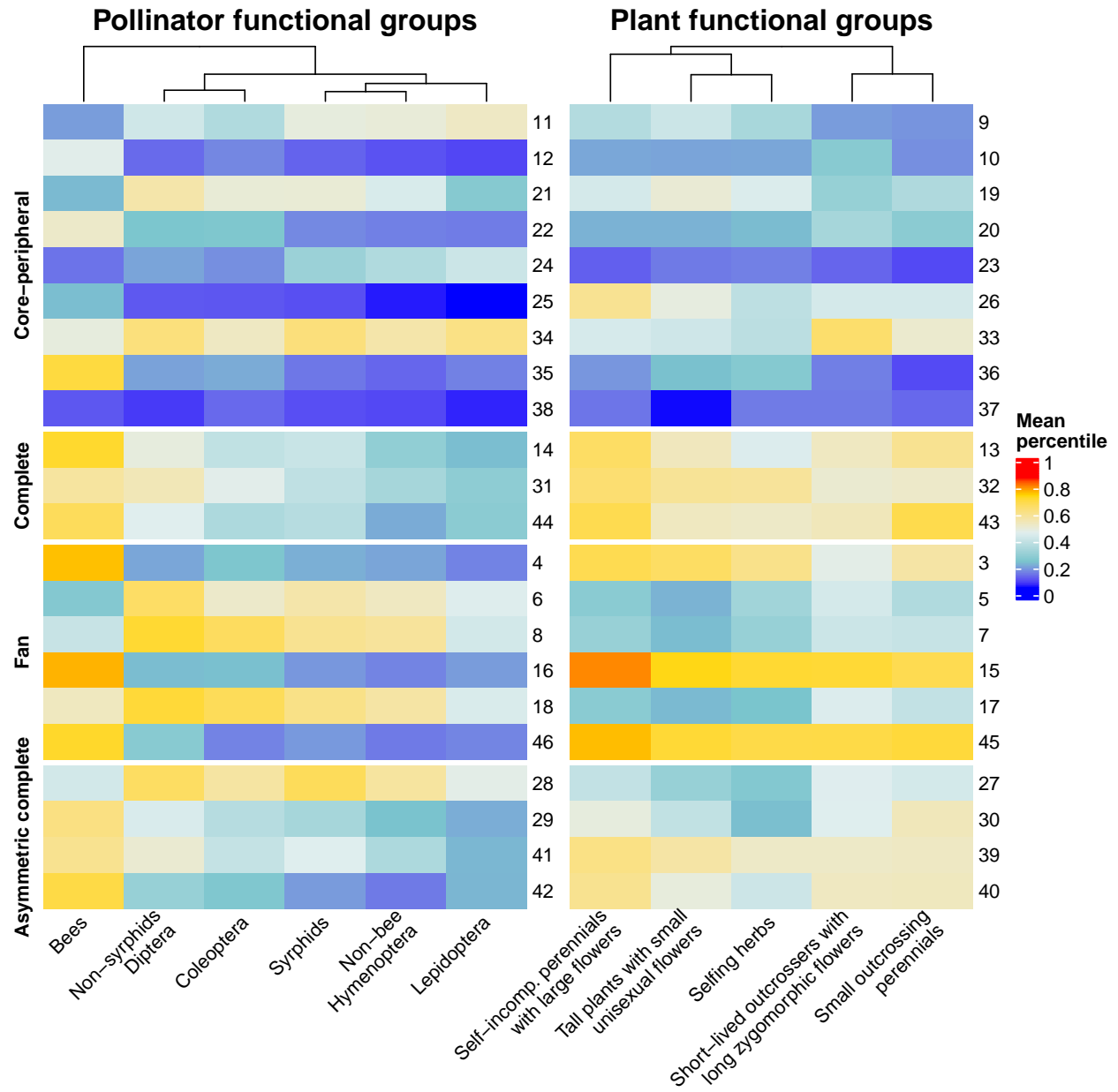
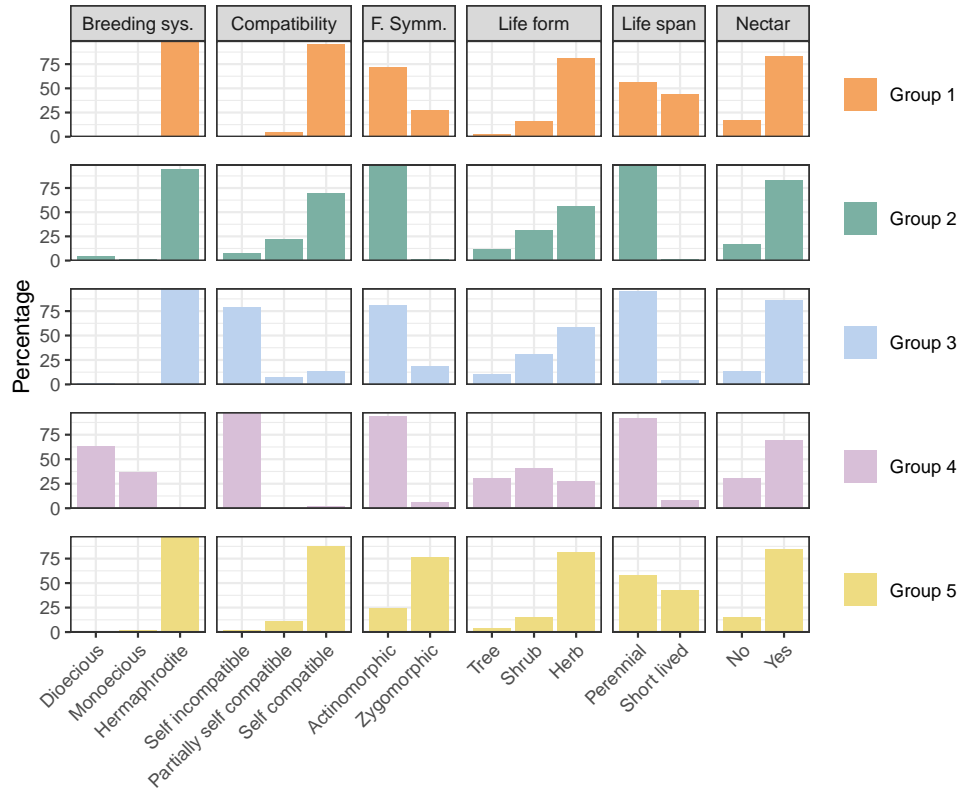


Figure S2. Heatmap indicating under- and over- representation of pollinator and plant functional groups in the different motif positions after removing non-robust links (singletons). The different motif positions are divided by the average path length classification by Simmons et al. (2020). The superior dendrogram indicates the differences across groups with the more separated groups showing larger differences.

Plant functional group composition

A) Qualitative variables



B) Quantitative variables

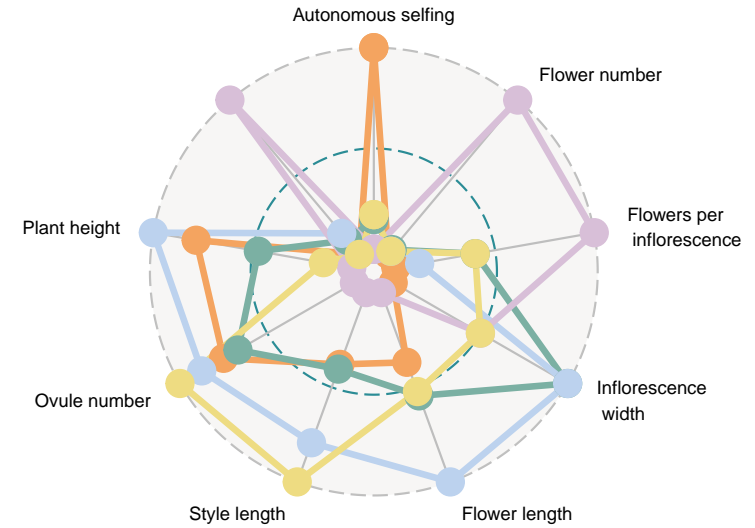


Figure S3. Plant functional group composition separated in qualitative and quantitative variables. Panel A) shows the percentage of the different categories within trait represented with different colours for each functional group. Plot B) shows the radar plot of the different quantitative variables standardized on the same scale also coloured with the same patterns of colours as qualitative variables per cluster or functional group. Group 1 corresponds to short-lived selfers; group 2 to small outcrossing perennials; group 3 to self-incompatible perennials with large flowers; group 4 to tall plants with small unisexual flowers; and, group 5 to short-lived outcrossers with long zygomorphic flowers.

Plant functional groups

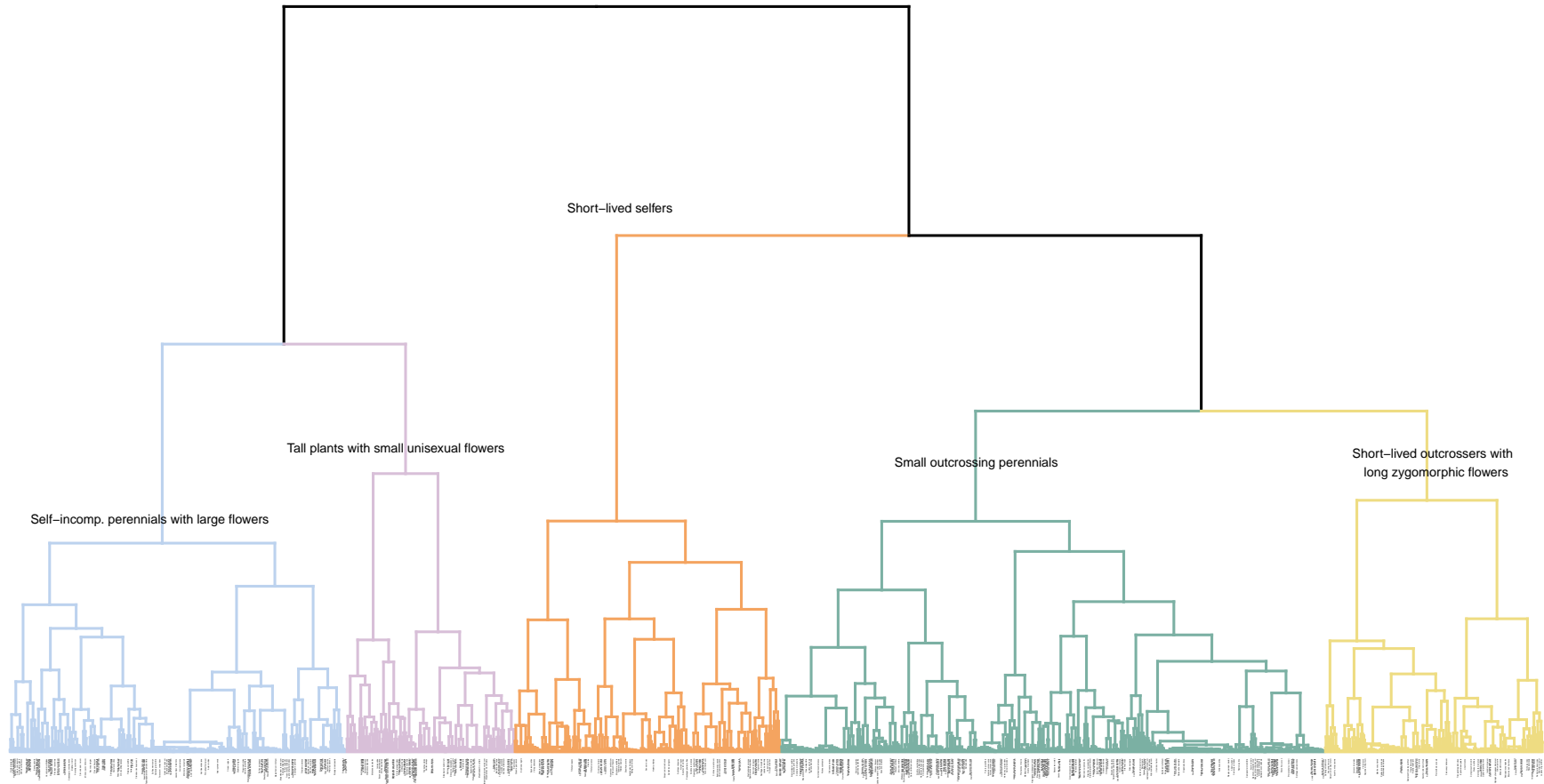


Figure S4. Hierarchical clustering dendrogram with the branches coloured by the optimal number of clusters (5). The labels of the subgroup of species ($N = 524$) used in this study are coloured in black in order to show the evenness of the distribution of the species across clusters. The rest of species labels are omitted for visualization purposes ($N = 982$).