# Supporting Information

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

#### **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 Map with the plant-pollinator study locations.
- Figure S2 Over and under-estimated motif frequencies.
- Figure S3 Over and under-estimated groups on motif positions.
- Figure S4 Plant trait composition of functional groups.
- Figure S5 Dendrogram with plant functional groups.
- Figure S6 Association between the percentile and specificity of the different plant and floral visitor groups on motif positions.
- Figure S7 Association between the percentile and number of indirect interactions of the different plant and floral visitor groups on motif positions.
- Figure S8 Frequency of floral visitor groups and number of indirect interactions per motif positions.
- Figure S9 Frequency of plant groups and number of indirect interactions per motif positions.

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Bundgaard	2003	1	Denmark	Unpublished, Master thesis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	$\rm https://doi.org/10.1126/science.1232728$
Dicks	2002	2	England	$\rm https://doi.org/10.1046/j.0021\text{-}8790.2001.00572.x}$
Dupont	2003	3	Denmark	$\rm https://doi.org/10.1111/j.1365\text{-}2656.2008.01501.x$
Elberling	1999	1	Sweden	$\rm https://doi.org/10.1111/j.1600-0587.1999.tb00507.x$
Fang	2008	1	China	https://doi.org/10.1111/1749-4877.12190
Inouye	1988	1	United States	$\rm https://doi.org/10.1111/j.1442-9993.1988.tb00968.x$
Kaiser-Bunbury	2017	8	Seychelles	$\rm https://doi.org/10.1038/nature 21071$
Kaiser-Bunbury	2011	6	Seychelles	$\rm https://doi.org/10.1111/j.1365\text{-}2745.2010.01732.x$
Kaiser-Bunbury	2010	2	Mauritius	https://doi.org/10.1016/j.ppees.2009.04.001
Lundgren	2005	1	Denmark (Greenland)	$\rm https://doi.org/10.1657/1523-0430(2005)037[0514:TDAHCW]2.0.CO; 2$
Olesen	2002	2	Mauritius and Portugal (Azores)	$\rm https://doi.org/10.1046/j.1472\text{-}4642.2002.00148.x$
Peralta	2006	4	Argentina	$\rm https://doi.org/10.1111/ele.13510$
Small	1976	1	Japan	/13960/t4 km 08d21
Souza	2017	1	Brazil	$\rm https://doi.org/10.1111/1365\text{-}2745.12978$

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	JIST.	$\alpha$	DIANT	species

Acantholippia seriphioides Achillea millefolium Achillea wilsoniana Aciphylla glacialis Aciphylla simplicifolia

Acrothamnus montanus Actaea yunnanensis Adenophora capillaris Adenophora jasionifolia Adenophora khasiana

Aeschynomene mollicula Agarista salicifolia Agrimonia pilosa Ajuga forrestii Allium ampeloprasum

Allium atrosanguineum Allium cyathophorum Allium wallichii Aloysia gratissima Alstonia macrophylla

Anacamptis morio Anaphalioides alpinum Anaphalis nepalensis Anchusa azurea Andromeda glaucophylla

Andryala integrifolia Anemone rivularis Anemonella thalictroides Angelica archangelica Anthriscus sylvestris

Antidesma madagascariense Antirhea borbonica Aphloia theiformis Arabis alpina Arachis microsperma

Arctium lappa Arctotheca calendula Arenaria yunnanensis Argusia argentea Armeria velutina

Arnica montana Aronia melanocarpa Asphodelus fistulosus Aster diplostephioides Aster oreophilus

Aster souliei Aster vestitus Erica umbellata Erigenia bulbosa Erophaca baetica Eryngium campestre Erythronium albidum

Erythrospermum monticolum Erythroxylum macrocarpum Erythroxylum sechellarum Eugenia kanakana Eugenia orbiculata

Euphorbia pyrifolia Euphorbia segetalis Euphrasia collina Euphrasia regelii Excoecaria benthamiana

Faujasiopsis flexuosa Filipendula ulmaria Flagellaria indica Freesia refracta Gaertnera petrinensis

Gaertnera psychotrioides Gaertnera rotundifolia Galactites tomentosus Galeopsis bifida Galium saxatile

Galium verum Gastonia crassa Gaylussacia baccata Geniostoma borbonicum Genista anglica

Genista hirsuta Genista pilosa Gentiana chunatie

Gentiana chungtienensis Gentiana crassicaulis Gentianella diemensis

Geranium delavayi Geranium maculatum Glionnetia sericea Gomphrena celosioides Gomphrena elegans

Grangeria borbonica Halenia elliptica Halimium commutatum Halimium halimifolium Hancea integrifolia

Harrimanella hypnoides Harungana madagascariensis Peponidium carinatum Pereskia sacharosa Persicaria runcinata Persicaria vivipara Phlomis atropurpurea

Phlomis purpurea Phlomis tatsienensis Phlox divaricata

Phoenicophorium borsigianum Phyllanthus phillyreifolius

Picris hieracioides Pilosella officinarum Pimelea ligustrina Pinguicula alpina Pittosporum senacia

Plantago lanceolata Pleurospermum davidii Pleurostylia leucocarpa Polemonium reptans Polyscias mauritiana

Portulaca fluvialis
Potentilla crantzii
Potentilla erecta
Potentilla fallens
Potentilla griffithii

Potentilla lancinata Potentilla rubricaulis Premna serratifolia Primula poissonii Primula secundiflora

Primula veris Prosopis flexuosa Prosopis rubriflora Prostanthera cuneata Prunella vulgaris

Pseudognaphalium affine Psiadia terebinthina Psidium cattleyanum Psychotria pervillei Psychotria terniflora

Pterocephalus hookeri Pyrola grandiflora Pyrostria bibracteata Pyrostria fasciculata Ranunculus acris

Ranunculus hispidus Reseda luteola Aster yunnanensis Astragalus alpinus Astragalus pullus

Atamisquea emarginata Ayenia tomentosa Azorina vidalii Badula insularis Badula platyphylla

Baeckea gunniana Bakerella hoyifolia Bartsia alpina Bertiera zaluzania Beta vulgaris

Bistorta macrophylla Bistorta sinomontana Bituminaria bituminosa Brassica fruticulosa Buddleja mendozensis

Calendula arvensis Calluna vulgaris Calophyllum eputamen Calopogon tuberosus Camassia scilloides

Campanula giesekiana Campanula rotundifolia Campnosperma seychellarum Camptosema paraguariense Canthium bibracteatum

Cardamine concatenata Carduus crispus Carpobrotus acinaciformis Casearia coriacea Cassiope tetragona

Castela coccinea Celmisia asteliifolia Celmisia graminifolia Centaurea nigra Cerastium alpinum

Cerastium fontanum Cereus hildmannianus Chamaedaphne calyculata Chamomilla suaveolens Chassalia coriacea

Chassalia petrinensis Chrysobalanus icaco Cinnamomum verum Cirsium arvense Cirsium eriophoroides

Cirsium palustre Cirsium pratense Helenium donianum Helichrysum proteoides Helichrysum stoechas

Herissantia nemoralis Herpetospermum pedunculosum Heteropterys glabra Hibiscus tiliaceus Hieracium praealtum

Hieracium umbellatum Homalanthus populifolius Hydrophyllum appendiculatum Hydrophyllum virginianum Hypericum perfolatum

Hypericum perforatum Hypochaeris radicata Impatiens chungtienensis Ipomoea macrantha Isostigma hoffmannii

Ixeridium biparum Ixora parviflora Ixora pudica Juncus allioides Kalmia angustifolia

Kalmia polifolia Kunzea muelleri

Larrea nitida

Labourdonnaisia calophylloides Larrea divaricata

Lathyrus clymenum Lathyrus pratensis Lavandula pedunculata Lavandula stoechas Lecanophora heterophylla

Ledum palustre Leontodon saxatilis Lepidaploa pseudomuricata Leptospermum scoparium Leucaena leucocephala

Leucanthemum vulgare Leucochrysum albicans Ligularia cymbulifera Ligularia dictyoneura Ligularia lankongensis

Lilium duchartrei Linaria viscosa Linum bienne Lippia alba Lobularia maritima

 $Lotus\ corniculatus \\ Lotus\ pedunculatus$ 

Rhododendron lapponicum Richea continentis Rosa rubiginosa

Roscheria melanochaetes Rosmarinus officinalis Roussea simplex Rubus alceifolius Rubus plicatus

Ruellia tweediana Ruta chalepensis Salix fragilis Salix lanata Salix polaris

Salix repens Salix reticulata Salvia przewalskii Sanicula odorata Saussurea wardii

Saxifraga aizoides Saxifraga oppositifolia Scabiosa atropurpurea Scabiosa stellata Scaevola taccada

Schinus fasciculata Scoparia montevidensis Scorzonera humilis Sedum roseum Sedum sediforme

Senecio lautus Senecio pinnatus Senna aphylla Sida rhombifolia Sideroxylon cinereum

Sideroxylon puberulum Silene acaulis Silene dioica Silene flos-cuculi Silene gracilicaulis

Silene suecica Silene vulgaris Silene yunnanensis Smilax anceps Solidago sempervirens

Solidago virgaurea Sonchus tenerrimus Soulamea terminaloides Spartium junceum Spenceria ramalana

Spermacoce eryngioides

Spiraea alba

Cirsium vulgare Cistus albidus Cistus crispus

Cistus ladanifer Cistus libanotis Cistus monspeliensis Cistus salviifolius Claoxylon linostachys

Claytonia virginica Cleistocactus baumannii Clematis akebioides Clematis campestris Cleome quianensis

Clinopodium repens Cnidoscolus urens Coccoloba guaranitica Codonopsis convolvulacea Coffea macrocarpa

Coffea mauritiana Colea seychellarum Condalia microphylla Convolvulus althaeoides Convolvulus arvensis

Corokia cotoneaster Craterispermum microdon Crepis capillaris Crithmum maritimum Croton fothergillifolius

Croton grangerioides Cuphea thymoides Cyananthus delavayi Cynoglossum amabile Daucus carota

Deckenia nobilis
Delphinium tricorne
Dianthus armeria
Dianthus caryophyllus
Diapensia lapponica

Dicentra cucullaria
Digitalis purpurea
Dillenia ferruginea
Dillenia suffruticosa
Diospyros revaughanii

Diospyros seychellarum Diplotaxis virgata Dipsacus asperoides Dipsacus chinensis Dodonaea viscosa

Doratoxylon apetalum Dorycnium pentaphyllum Lupinus angustifolius Lycium chilense Lysimachea europaea

Maianthemum racemosum Maianthemum trifolium Malva multiflora Medusagyne oppositifolia Melampyrum pratense

Melicope chapelieri Melicope lunu-ankenda Memecylon eleagni Memecylon ovatifolium Menodora decemfida

Mentha canadensis Mertensia virginica Microseris lanceolata Microtea scabrida Microula sikkimensis

Mimosa hexandra Mimosa sensibilis Mimulus moschatus Mimusops erythroxylon Mimusops sechellarum

Molinaea arborea Molinaea macrantha Mollugo verticillata Monarda bradburiana Morinda citrifolia

Muehlenbeckia axillaris Muehlenbeckia complexa Murdannia nudiflora Mycelis muralis Myosotis alpestris

Nematolepis ovatifolia Nemopanthus mucronatus Nepenthes pervillei Nepeta stewartiana

 $Nephrosperma\ vanhoutteanum$ 

Neptunia plena Northia seychellana Ochna kirkii Ochna mauritiana Ocotea laevigata

Olea lancea Olearia bullata Onosma confertum Opuntia elatior Opuntia stricta

Opuntia sulphurea Origanum vulgare Stachys sylvatica Stachytarpheta indica Stachytarpheta jamaicensis

Stellaria graminea Stellaria yunnanensis Stillingia lineata Stylosanthes hamata Succisa pratensis

Suriana maritima Swertia forrestii Syzygium commersonii Syzygium coriaceum Syzygium glomeratum

Syzygium jambos Syzygium mauritianum Syzygium petrinense Syzygium venosum Syzygium wrightii

Tabernaemontana persicarifolia Talinum fruticosum Tambourissa peltata Taraxacum campylodes Teucrium fruticans

Thalictrum delavayi Thalictrum rostellatum Thapsia villosa

Thespesia populnea Thymelaea hirsuta

Thymus mastichina Tibetia himalaica Tillandsia didisticha Timonius sechellensis Toddalia asiatica

Torilis japonica Tradescantia virginiana Trifolium arvense Trifolium dubium Trifolium pratense

Trifolium repens Tripogandra glandulosa Tristemma mauritianum Trochetia blackburniana Trollius europaeus

Trollius vaginatus Tuberaria guttata Turnera angustifolia Turraea rigida Ulex parviflorus

Urospermum picroides Uvularia grandiflora Dracaena concinna
Dracaena reflexa
Dryas integrifolia
Dryas octopetala
Dubyaea bhotanica
Echinopsis candicans
Echinopsis rhodotricha
Echium plantagineum

Echium sabulicola Eleutherine bulbosa Embelia angustifolia Empetrum nigrum Enemion biternatum

Epacris petrophila Epilobium angustifolium Epilobium gunnianum Epilobium hirsutum Epilobium latifolium

Epilobium tibetanum Erica scoparia Erica tetralix Orites lancifolius Oxalis violacea Oxylobium ellipticum

Ozothamnus leptophyllus Pandanus barkleyi Pandanus rigidifolius Pandanus wiehei Paragenipa wrightii

Paraserianthes serratifolia Parkinsonia praecox Parnassia palustris Passiflora suberosa Pavonia sidifolia

Pedicularis cephalantha Pedicularis densispica Pedicularis dichotoma Pedicularis rex

Pedicularis siphonantha Pedicularis tricolor

Pemphis acidula Pentachondra pumila Vaccinium myrtilloides Vaccinium myrtillus Vaccinium uliginosum Vaccinium vitis-idaea

Verbascum thapsus Veronica brachysiphon Vicia cracca

Vicia lutea
Vicia sativa
Viola biflora
Viola pubescens
Viola sororia

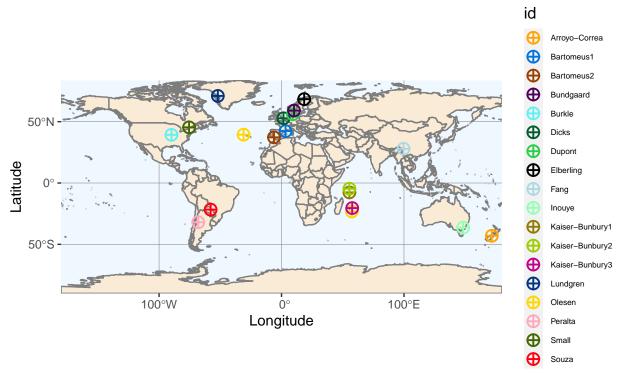
 $Wahlenbergia\ albomarginata$ 

Wahlenbergia ceracea Waltheria indica Warneckea trinervis Wikstroemia indica Xylopia lamarckii

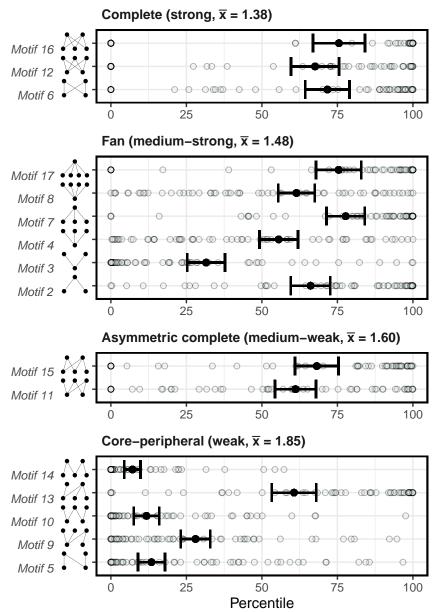
Ziziphus mistol Zuccagnia punctata

**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.** Map with the different locations of the plant-pollinator studies used in this work to explore woldwide patterns at the meso-scale level. For each study just one location is shown except for the study of Olesen that was conducted in two very different locations (Mauritius and Azores).



**Figure S2.** 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 singletones. 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).

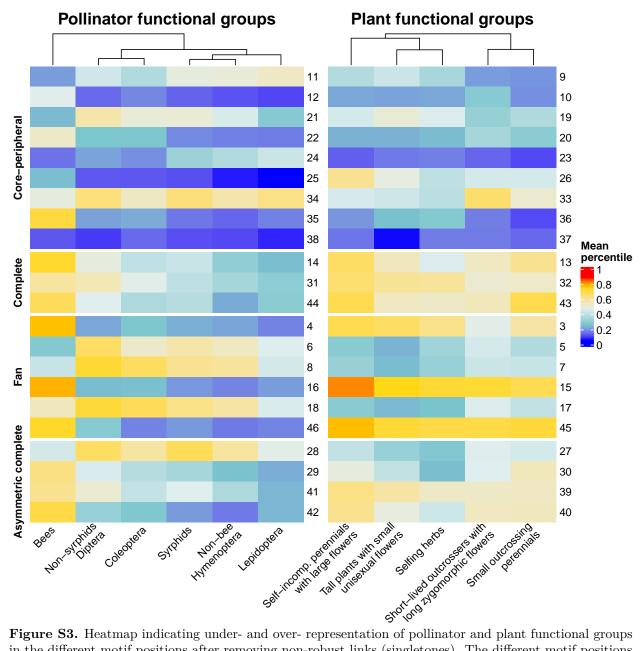


Figure S3. Heatmap indicating under- and over- representation of pollinator and plant functional groups in the different motif positions after removing non-robust links (singletones). The different motif positions are divided by the average path length clasification by Simmons et al. (2020). The superior dendrogram indicates the differences across groups with the more separated groups showing larger differences.

## Plant functional group composition

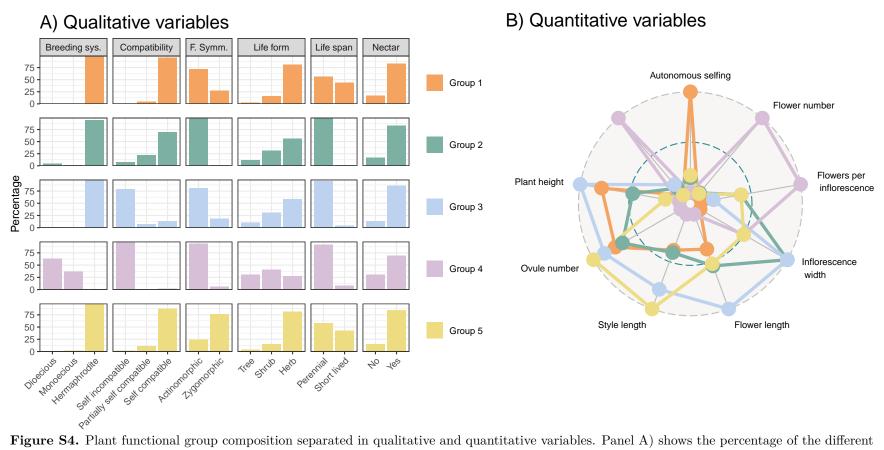
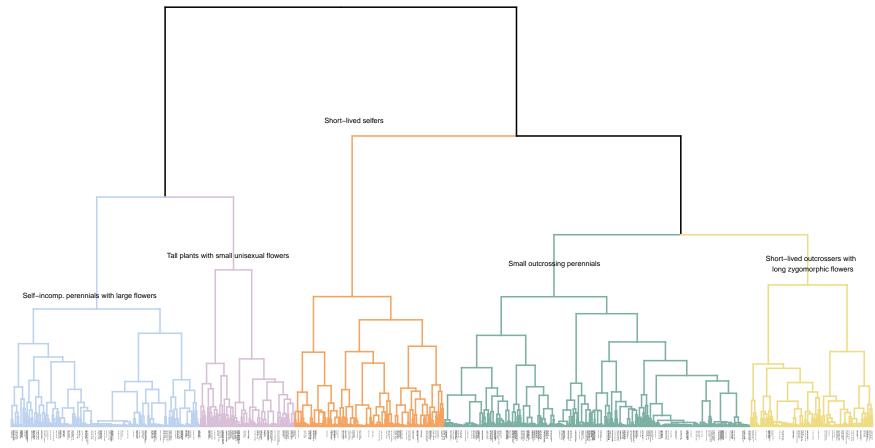


Figure S4. Plant functional group composition separated in qualitative and quantitative variables. Panel A) shows the percentage of the different categories within trait represented with different colours for each functional group. Plot B) shows the radar plot of the different quantitative variables standardize 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 S5.** 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).

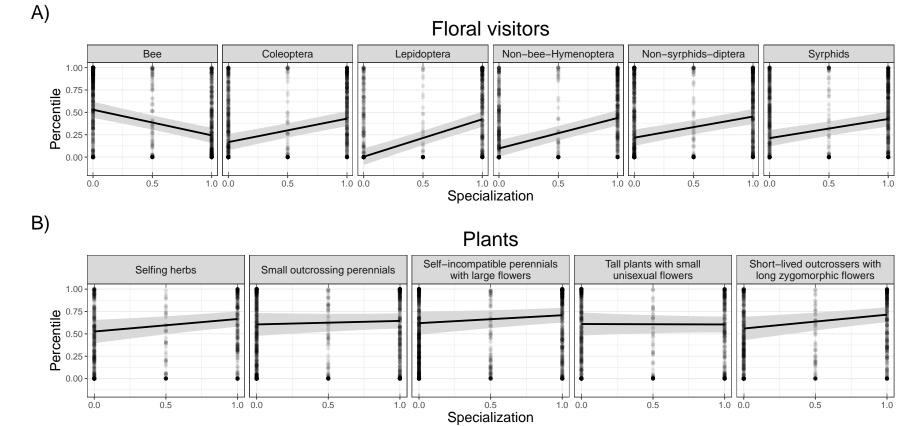


Figure S6. Association between the percentile and specialization of the different plant and floral visitor groups on motif positions

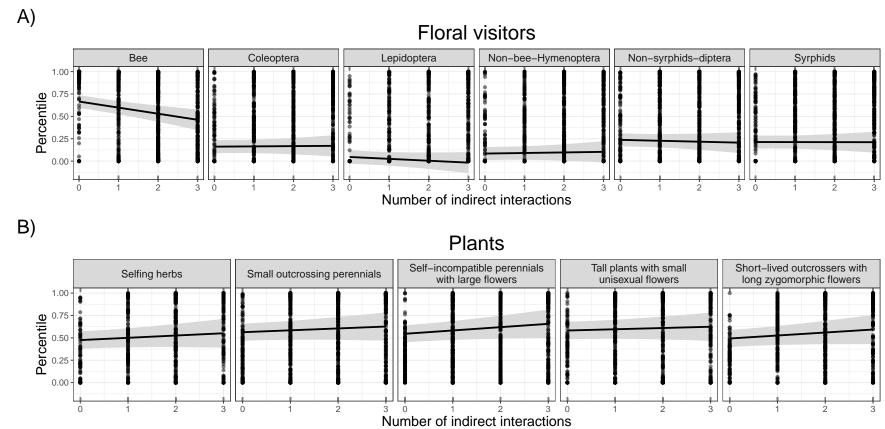
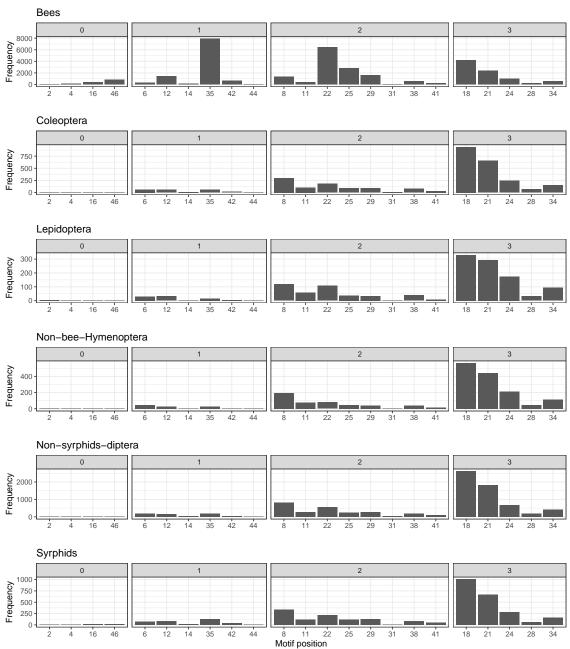


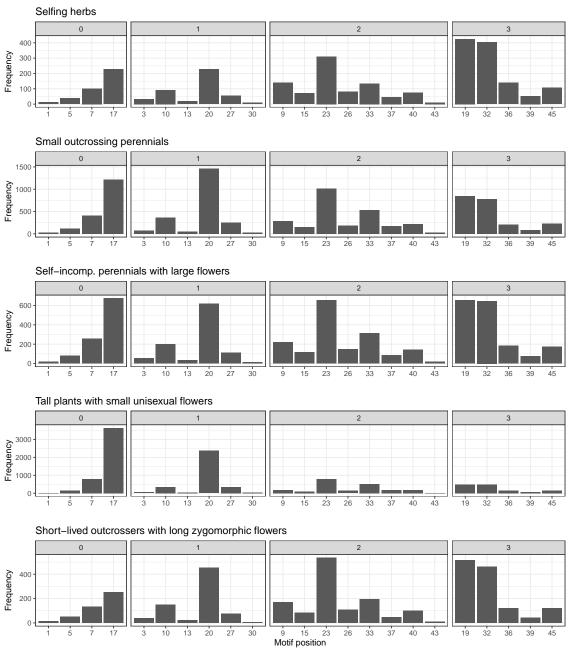
Figure S7. Association between the percentile and number of indirect interactions of the different plant and floral visitor groups on motif positions

### Floral visitors Number of indirect interactions (0, 1, 2, 3)



**Figure S8.** Frequency of the different floral visitor groups on the different motif positions aggregated by the number of indirect interactions for the different motif positions.

### Plants Number of indirect interactions (0, 1, 2, 3)



**Figure S9.** Frequency of the different plant groups on the different motif positions aggregated by the number of indirect interactions for the different motif positions.