The role of exotic species in pollination networks: implications of plant functional traits

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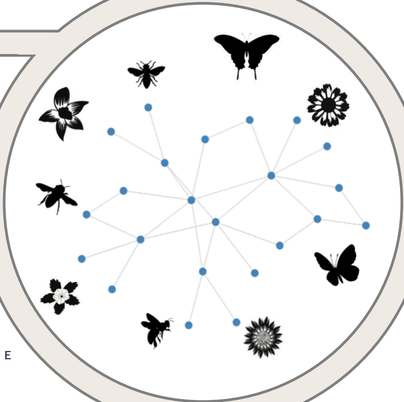
Biological invasions represent a major threat to biodiversity as they can alter the structure and functioning of ecosystems by modifying different ecological processes[1]. The integration of exotic species into plant-pollinator communities has been frequently investigated using a mutualistic network approach[2]. Previous studies demonstrated that invasion of species and their interactions significantly alter pollination network structure, hence the study of the network role of exotic and native species helps to define the way they shape these networks[3]. Nevertheless, the topological properties of mutualistic networks result in part from complementary traits of species since they influence the network position of species by mediating interactions[4]. Because exotic and native species usually differ in functional traits[5] their contribution to the network structure may be different.

OBJECTIVES

1. To test whether exotic and native species of plants and pollinators play different roles in the structure of pollination networks.
2. To investigate whether there are differences in functional traits between exotic and native plant species. As functional traits may be phylogenetically constrained, I accounted for the phylogenetic signal of these traits.
3. To assess whether functional traits of plant species can determine their network roles, and thus, how exotic plant species traits may influence their integration into pollination networks.



MATERIALS AND METHODS

STUDY SITE AND DATASET

Quantitative pollination networks from the South Island of **New Zealand** (Carine Emer, unpublished data).

3 different sites (distant 1 km apart) sampled 4 times during the summer season (2012-2013): 12 networks.

 34 species ➡ 23 exotic species (of which ≈50% were Asteraceae)

 100 species ➡ 14 exotic species (of which ≈30% were Apidae)

① NETWORK ROLE

It was defined by a set of species-level metrics ('Bipartite' R package):

Metric	Description	Analysis
Normalized degree	Number of observed links per species	Differences between exotic and native species: Generalized Linear Mixed Models (GLMMs) Time nested within site as a random effect
Specialization (d')	Degree of specialization of each species	
Species strength	Sum of all interaction partners' dependences on that species	

② PLANT FUNCTIONAL TRAITS

Plant growth type
Stigma position
Flower symmetry
Flower colour

❯ Multivariate space: Multiple Correspondence Analysis (MCA) ('FactoMineR' R package)

❯ Differences between exotic and native species (MCA dimensions): Mann-Whitney U tests

Phylogenetic signal: building phylogenies of plant species - distances assessed as millions of years of divergence - and using Blomberg's K ('phytools' R package).

R codes created available on GitHub:

③ NETWORK ROLE vs FUNCTIONAL TRAITS OF PLANTS

Pearson's correlation tests between species-level metrics and MCA dimensions.

RESULTS

① NETWORK ROLE

Exotic and native species played different roles, but exotic plants showed the opposite trend than exotic pollinators (Fig. 1).

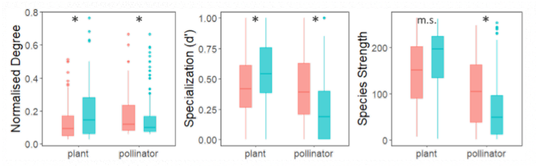


Figure 1. Boxplots of species-level metrics for exotic (red) and native (blue) plant and pollinator species. *Significant results (*P*<0.05), "m.s." Marginally significant results (0.05<*P*<0.09).

② PLANT FUNCTIONAL TRAITS

Exotic and native plant species differed in functional traits for MCA dimension 1 (*P*=0.007) and dimension 2 (*P*=0.006) (Fig. 2).

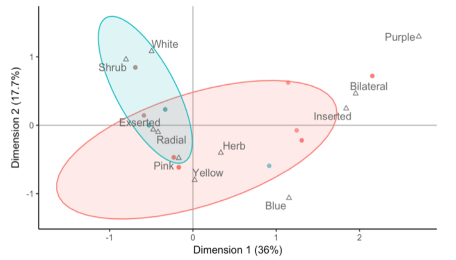
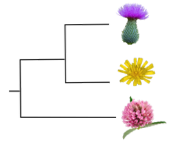


Figure 2. Plant functional traits' MCA, percentage of explained variance is included in brackets. Red points and ellipsoids represent exotic species, while the blue ones represent native species. Triangles mark functional traits according to their contribution to MCA dimensions.

PHYLOGENETIC SIGNAL

MCA Dimension 1 — *P*=0.002
MCA Dimension 2 — *P*=0.009
➡ Blomberg's K <1

The phylogeny revealed the existence of two exotic taxonomic groups (Fabaceae and Asteraceae families) sharing functional traits



③ NETWORK ROLE vs FUNCTIONAL TRAITS OF PLANTS

Table 1. Results of Pearson's correlation analyses between species-level metrics and MCA dimension 1 (a) and dimension 2 (b). Significant (*P*<0.05) and marginally significant results (0.05<*P*<0.09) appear in bold.

a	Pearson's coefficient	t	*P*
Normalized degree	-0.317	-1.891	**0.068**
Specialization (d')	0.299	1.733	**0.086**
Species strength	-0.265	-1.556	0.130

b	Pearson's coefficient	t	*P*
Normalized degree	0.289	1.709	0.100
Specialization (d')	0.389	2.392	**0.023**
Species strength	0.398	2.452	**0.020**

NORMALIZED DEGREE ⇕ FLOWER SYMMETRY, STIGMA POSITION

SPECIES STRENGTH ⇕ FLOWER COLOUR, GROWTH FORM

SPECIALIZATION (d') ⇕ FLOWER SYMMETRY AND COLOUR, GROWTH FORM, STIGMA POSITION

DISCUSSION

1. The network role of exotic species depends on the guild considered. The results for exotic plants are consistent with invasion ecology studies, as the higher generalization level determines their ability to establish in the community. However, exotic pollinators are more specialized because they usually interact with a few exotic plant species from the same geographic range.
2. Exotic plant traits may facilitate the disruption of plant-pollinator interactions in the native community. It is likely that exotic and native plants do not share functional traits despite having a recent common ancestor as they have evolved under different selective pressures. The phylogeny disclosed two groups of exotic species according to functional traits and these traits shared by certain taxonomic groups might enhance their establishment.
3. The association between plant functional traits and network roles is related to the geographic origin of interacting species and the ability of native species to persist in the community. Although functional traits of plants may determine their network role, the predictability of exotic species' roles considering traits has strong limitations.

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