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Structural dynamics of a Mediterranean pollination network

The influence of flowering phenology on the community structure

1. INTRODUCTION

In pollination networks plant and insect species are represented by nodes and their interactions are links that describe the use of plant resources by pollinators (Fig. 1, Fig. 2). The network approach to plant-pollinator systems allows analyzing the structure of these communities, which is fundamental for their conservation [1].

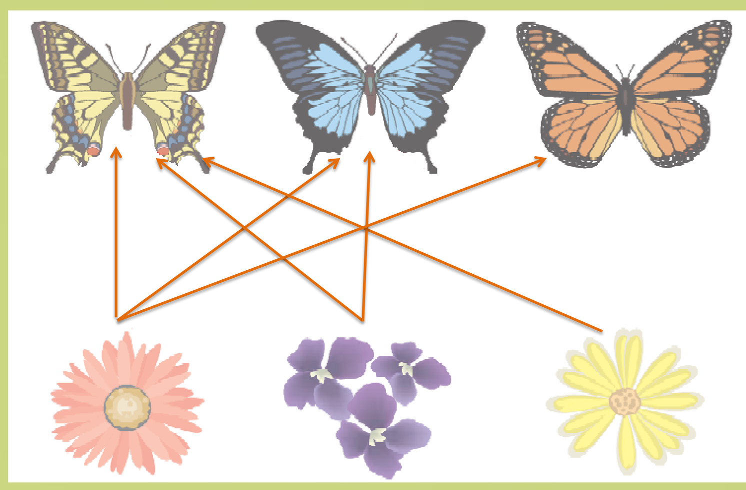

Figure 1 Representation of a simple pollination network (*modified from* [1]).

Figure 2 The honeybee (*Apis mellifera*) is a common pollinator in Mediterranean communities [2].

2. STARTING POINT

The Mediterranean plant-pollinator community of the Natural Park of Garraf follows a strong seasonality affecting both flower availability and as a consequence the frequency of visits by pollinators (Fig. 3). Thus, three phenological periods are identified, each of them showing a distinct scenario concerning plant-pollinator relationships:

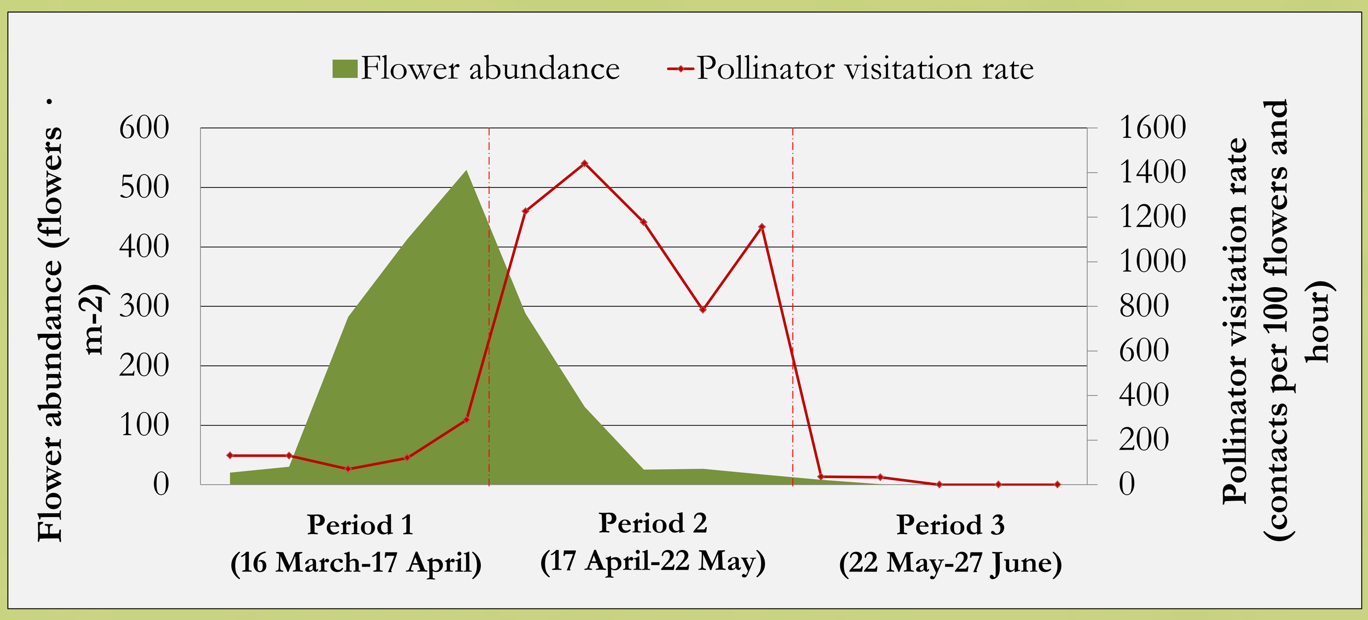

Figure 3 Representation of the seasonal pattern of flower abundance and pollinator visitation rate in the Garraf plant-pollinator community during the flowering season in 2006. Note that as flowers drop in abundance pollinators increase in frequency of visit (there are fewer flowers per pollinator).

3. AIMS AND HYPOTHESES

(1) The study aims to represent and describe the structure of the interaction networks of three different phenological periods.
(2) It aims to identify if there is a substantial change in the network structure between periods.
(3) It aims to understand how flower abundance and pollinator visitation frequency affect the network structure.

THE MAIN HYPOTHESIS: Pollinators will generalize their diet towards the second period since each plant species won't be abundant enough to sustain their requirements. This is expected to influence the overall network structure. In the third period too few plants and pollinators remain so it is not expected any significant pattern.

4. METHODS

FIELD WORK → Six weekly 50x1m transect field samplings in the Mediterranean scrubland of the Natural Park of Garraf (March-June 2006).

- **Countings of the number of open flowers in the transects.**
- **Countings of all the flower-pollinator contacts in the transects.**

Figure 4 *Cistus albidus. (From the author).*

*NETWORK STRUCTURE METRICS

Connectance: The proportion of realized links from the total of possible links within the network.
Network size: The species richness of the network, the more plant and pollinator species, the bigger the network is.
Nestedness: In a nested network generalists interact with both generalists and specialists, but few interactions occur between specialists (Fig. 1).
Interaction strength asymmetry: It shows the dependence between plants and pollinators (e. g. if very few plants monopolize all the interactions, pollinators are dependant on these plants so this parameter will be positive).
Specialization parameters: *H2'* at the network level and *d'* at the species level, indicate how frequent specialist interactions are.

Figure 5 *Papilio machaon (From the author).*

Database with 4253 flower-pollinator contacts, involving 124 pollinator species and 19 plant species.

CALCULATION OF NETWORK AND SPECIES PARAMETERS* (*see Network structure metrics*): Network level and species level functions with the Bipartite package in R software.

STATISTICAL ANALYSIS

NETWORK REPRESENTATION (Fig. 6): Plotweb function with the Bipartite package in R software.

Paired t-tests with the *d'* Specialization Index* (*see Network structure metrics*) for the 23 shared pollinator species between periods one and two.

5. RESULTS

Networks one and two had a very similar structure, both having a central interaction and a majority of weak ones (Fig. 6a, 6b). Network metrics such as connectance, nestedness and web specialisation kept very constant between periods one and two whereas interaction strength asymmetry decreased (Table 1).

The third period had only three flowering species and very few pollinators. In addition, these plant species had very low abundance, characterizing a food scarcity period for pollinators (Fig. 1, fig. 6c).

PERIOD 1

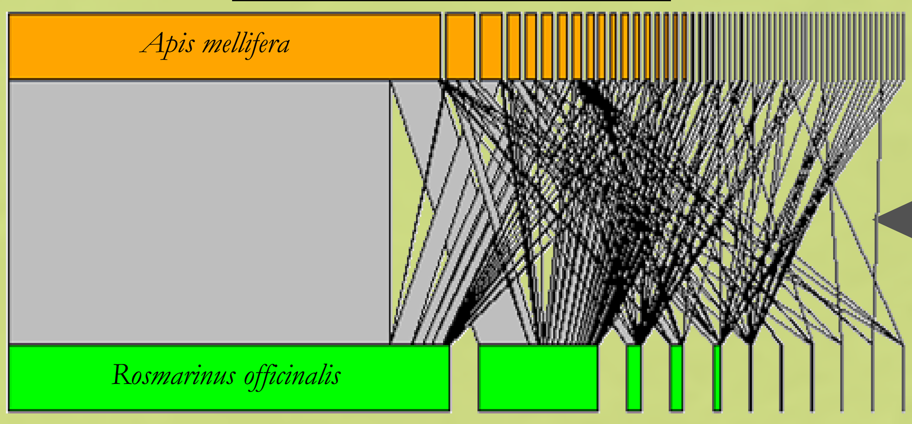

Figure 6a Interaction network of the first period.

NETWORK SIZE: 11 plants and 57 pollinator species.
The *Rosmarinus officinalis - Apis mellifera* is the central interaction of the network.

POLLINATOR SPECIES
FREQUENCY OF INTERACTION
PLANT SPECIES

PERIOD 2

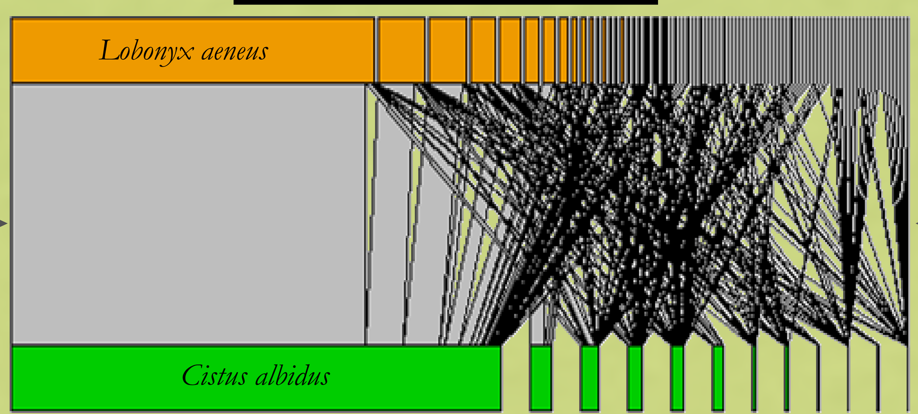

Figure 6b Interaction network of the second period.

NETWORK SIZE: 12 plants and 89 pollinator species.
The *Cistus albidus - Lobonyx aeneus* is the central interaction of the network.

POLLINATOR SPECIES
FREQUENCY OF INTERACTION
PLANT SPECIES

PERIOD 3

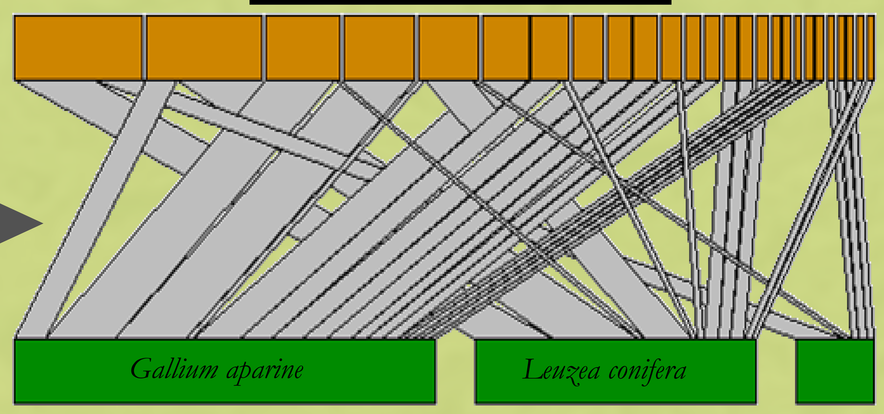

Figure 6c Interaction network of the third period.

NETWORK SIZE: 3 plants and 26 pollinator species.
No central interaction is found in the network.

	Network 1 (16 March-17 April)	Network 2 (17 April-22 May)	Network 3 (22 May-27 June)
Number of interactions	109	205	33
Connectance	0.17	0.19	0.42
Nestedness	17.79	21.51	16.58
Interaction strength asymmetry	3.80	-0.65	-0.79
Web specialisation (*H2'*)	0.46	0.52	0.66

NETWORK METRICS VALUES OF EACH PERIOD

Table 1 Comparison of the main network metrics between periods. See *Network structure metrics** for information about the parameters.

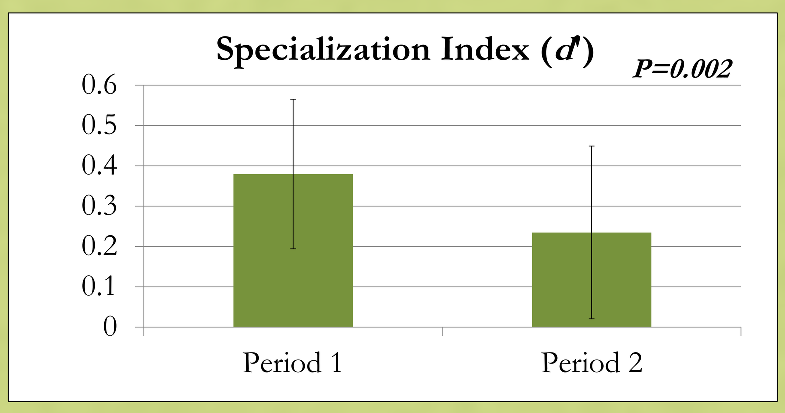

Figure 7 Bar graph showing a significant decrease in the specialization level of pollinators towards period two.

POLLINATORS VISITED A WIDER VARIETY OF PLANT SPECIES WHEN THERE WERE FEWER FLOWERS AVAILABLE (PERIOD 2)

6. CONCLUSIONS

LESS FLOWER AVAILABILITY WAS LINKED TO POLLINATOR GENERALIZATION

(1) Pollinators increased remarkably their generalization towards period two (Fig. 7), suggesting that **too few flowers available forced pollinators to visit a wider variety of plant species**. This is consistent with the main hypothesis.
(2) As a result of the pollinator generalization, **pollinator species played an important role for plants during the second period** (Int. strength asymmetry= -0.65) **whereas in the first one pollinators were highly dependent on plants for surviving** (Int. strength asymmetry= 3.80) (Table 1).

POLLINATION NETWORKS HAVE A VERY ROBUST STRUCTURE

(1) Although pollinators generalized their diet in period two, **this was not influential on the overall network structure and therefore networks one and two were very similar**. A constant *H2'* at the network level (i. e. network specialization kept almost constant) and a significant change at the *d'* index for pollinators (i. e. pollinators increased in generalisation) support this fact, showing that **plant abundance and visitation frequency affected the pollinator level but not the network level**.
(2) Different network size, flower abundance and species composition between periods one and two did not affect network structure, meaning that **these communities have a very intrinsic and constant structure**. This is very relevant for their conservation since this makes them very robust to perturbations [3].

REFERENCES

(1) Rohr, R., Saavedra, S. & Bascompte, J. (2014), *On the structural stability of mutualistic systems*, Science 345, DOI: 10.1126/science.1253497.
(2) Perilous Adventures (2014). Posted on September 9 2014.http://www.perilousadventures.net/blog/?p=1348.
(3) Saavedra , S. et al. (2011), *Strong contributors to network persistence are the most vulnerable to extinction*, Nature 478, DOI: 10.1038/nature10433.