Linking bees and flowers: mutualistic interaction networks to study ecosystem functioning

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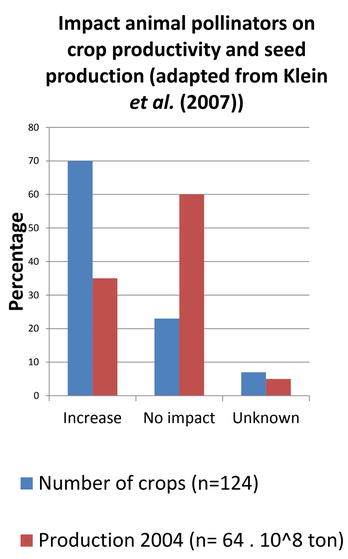
In recent years, much attention is going to pollinators, as they are important for the increasing food production while being threatened by agricultural intensification and other environmental drivers. In pollination and pollinator research, often not only pollinators but also plants are considered. Plants provide pollinators with pollen and nectar, while pollinators aid in plant reproduction by transporting pollen. This mutualistic interaction process is structured in a network between plants and pollinators.

Plants and pollinators

Plants

- Need **pollen** to be transported for sexual reproduction
- **Wind** pollinated or **animal** pollinated
- Can have attractive shapes and colors to attract pollinators
- Produce **floral rewards** (nectar and pollen) for flower visitors
- Specialist or generalist in their pollinators
- **Wild plants**: 60-80% depend on animal pollination
- **Crops**: see graph (number vs production)
- Increasing pollination demand of agriculture



Pollinators

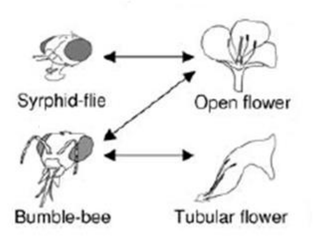
- Bees, syrphid flies, butterflies, moths, wasps, flies, ants, (bats, birds, mammals)
- **Bees**:
  - Honeybee (*Apis mellifera*) + ca. 375 wild bee species in Belgium
  - Active pollen collectors
- Generalist vs. specialist for plant species
- Looking for **flower rewards**: pollen (protein source), nectar (sugar source), flower oil (some species)
- Slow increase of bee hives, extinction or decrease of some wild pollinators during last decades

Mutualistic interaction networks for dummies

Network structure

When putting **plants** and **pollinators** together in an **interaction** network, not all pollinators species will visit all plant species and not with equal frequency:

- **Competition** between pollinators for a plant or between plants for a pollinator
- Flower **preferences** by pollinators because of flower **traits** (cf. pollination syndrome). E.g. corolla depth: open flowers with easily accessible nectar vs. tubular flowers with deep nectar source.

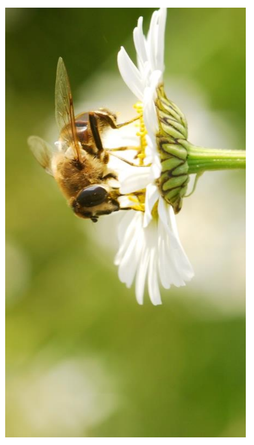


Fontaine *et al.*, 2006

Sampling method

To map the interaction network you need to know which **links** between plants and pollinators exist (qualitative network) and how many **interactions** occur between the plant species and the pollinator species for each link (quantitative network). Different methods exits:

- Transects, quadrats, individual plants
- Timed observations per plant species
- Identify to species or not
- Hand netting/ suction sampler
- Identify pollen on the pollinators

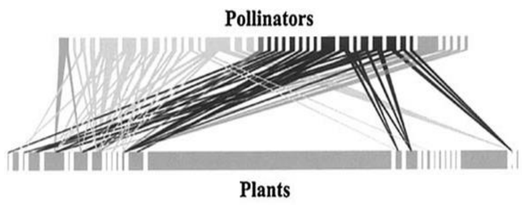


Analysis and applications

Analysis

Visualization

Visual representation of network with plant species and pollinator species shown as blocs, length of the blocks showing the respective abundance of the species, thickness of the links showing the amount of interactions between 2 species. See figure



Example of visual representation (Forup and Memmott, 2005)

Indices

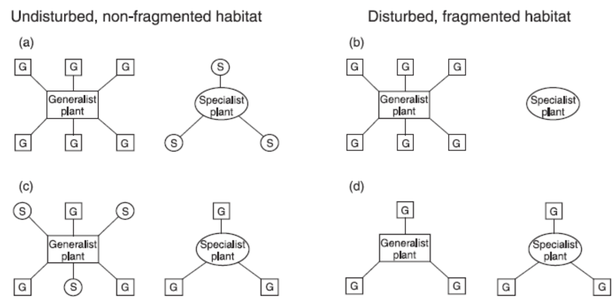
Based on network data, a lot of indices can be derived, amongst which 2 popular:

- **Connectance**: the proportion of all possible links that is realized in the network
- **Nestedness**: the degree to which species with few links have a sub-set of the links of other species, rather than a different set of links

Applications

Use

- Identify **keystone** species
- Evaluate **resilience** of ecosystem functioning
- Identify plants or pollinators that are indirectly crucial for a plant or pollinator through the network links



Theoretical consequences of asymmetric specialization for habitat disturbance and fragmentation: 'G' and 'S' represent respectively generalist and specialist pollinators, (a) and (b) are symmetrically specialized networks, (c) and (d) are asymmetrically specialized networks. (Ashworth *et al.*, 2004)

Important outcomes

- Plants and pollinators **more generalized** than thought based on pollination syndromes
- **Asymmetric** specialization: plants specialized in their pollinators mostly have a generalist pollinators, specialist pollinators often mostly visit plant species that are generalist in their pollinators (see figure).

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