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How local plant community and landscape context affect the morphological space of wild bee communities in grasslands?

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General context

Growing concern about wild pollinator loss and the consequences for pollination service in intensive agricultural landscapes (eg. Biesmeijer et al. 2006, Degove et al. 2014, Potts et al. 2016)

Land-use intensification affects wild bee communities through habitat loss and fragmentation at the landscape scale (Bannemar et al. 2010, Kennedy et al. 2013); and less diverse plant communities at the local scale (De Palma et al. 2015, Rader et al. 2014)

Such disturbances are not expected to affect all bee species identically, rather they are likely to be mediated by the species’ traits (De Palma et al. 2015, Kousen 2002, Murray, Kulmz & Potts 2008)

Which traits may be involved in the response of wild bee communities to land-use intensification?

• Body size and dispersal traits (Gerswehr et al. 2007)
• Resource acquisition traits (Kulmz et al. 2007)
• Tongue length
• Prementum length

Co-variation among wild bee morphological traits (PCA)

Traits covary along three axes:

- Axis 1: Body size and dispersal traits
- Axis 2: Tongue length and resource acquisition traits
- Axis 3: Prementum length and body shape traits

In the subsequent analysis, we considered three independent traits:

finder grassland (ITD), related to dispersal abilities
geometric ratio between tongue length and body size
geometric ratio between prementum length and body size

Material & methods

Study area

• 450 km²
• Intensive agro-ecosystem
• Semi-fragmented landscapes
• Sown and permanent grasslands

In August 2014, 40 grasslands sampled

• Plant survey (specific composition, percent cover species)
• Bee survey (trapped with colored pan-traps)
• Landscape metrics in 1000m buffers (% grassland, % annual crop, % wood)

Measures of bee traits

• 30 individuals selected randomly within each grassland, when it was possible
• In total, 1050 individuals measured

Flower traits extracted from Bioflor (Site et al. 2003)

• Phenological traits (flowering begin, flowering end)
• Bee dependence traits (computed according to Collins et al. 2014)
• Flower colour

Characterization of bee and plant communities

• Community Weighted Mean trait (CWM) (Vesk et al. 2010)
• Community Weighted Variance (CWV)
• Multi-trait functional diversity (FDs) (Legendre & Leprieur 2010)

Statistical analyses

• Morphological space, occupied by all individuals belonging to a grassland, was estimated using the R hyperspace package (Bouvier et al. 2014)
• Linear models included:
  - Landuse diversity score (grassland, CWM flowering traits, CWM flowering end, CWM bee dependence)
  - Landscape factors (% crop, % grasslands, % wood)
  - Local factors: (age of the grassland)
  - Covariates (crop Environmental LTER ZA PVS 2014-2012)
• Best model selected with the Maximum likelihood test and Akake information criterion
• Null model approach for examining the possible reduction of trait ranges in grasslands.
We used the R rfit package (Bouvier & Vesk 2010) and the community-wide variance relative to the local variance of the regional pool (E2M) (Vesk et al. 2012)

Results and discussion

1. Trait by trait (CWM and CWV)

• The diversity of traits related to dispersal abilities is lower in landscapes mostly composed of crop. In disturbed landscapes, individuals with low dispersal abilities may not reach the grasslands (Kousen et al. 2002, Wright, Roberts & Collin 2015) and diversity of dispersal traits will be lower in the focal grassland.
• No significant effect on the CWM

2. Morphological space (hypervolume)

• Morphological space with high proportion of grassland, the morphological space occupied by the wild bee community is higher. This may also suggest mass-effect dynamics.
• In grasslands with high flower diversity, and so high resource, the morphological space is higher.
• When the plant community is highly dependent of bees for pollination, the morphological space is smaller.

Fig. 2. The study area (Emile-Roux).2

Conclusion

• Importance of considering multiple scales and multiple interacting traits to understand the composition of local communities and their responses to land use intensification.
• Landscape factors affect particularly the diversity of bee traits. Especially, grasslands provide a spillover of individuals with diverse resource acquisition traits through a mass-effect (Schaeda & Ellenberg 1984).
• External environmental filtering is detected when considering the morphological space instead of considering each trait separately. This suggests that the environment filters wild bees according to different trait combination and strategies.