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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 (e.g., Boschmeijer et al. 2006, Depauw et al. 2014, Potts et al. 2016)

Land-use intensification affects wild bee communities through habitat loss and fragmentation at the landscape scale (Bannemaro 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, Kuhlmann & Potts 2008)

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

- Body size and dispersal traits (Gerszewski et al. 2007)
  - Body length
  - Wing length
  - Distance between wing bases (Inter-Tegular Distance)

Co-variation among wild bee morphological traits (PCA)

- Traits covaraint 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:

1. Inter-Tegular distance (ITD), related to dispersal abilities
2. Allometric ratio between tongue length and body size
3. Allometric ratio between prementum length and body size

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 (Straverkaul et al. 2020, Wright, Roberts & Collins 2015) and diversity of dispersal traits will be lower in the focal grassland.

- No significant affect on the CWM

2. Morphological space (hypervolume)

- In grasslands with high flower diversity, wild bees tended to have smaller prementum. Species with small prementum may be dependent of flower with high nectar accessibility. Thus, high resource diversity may allow individuals with small prementum to found their resource in the grassland.

- The diversity of this traits related to resource acquisition is also higher in landscapes with high proportion of grassland.

Material & methods

Study area

- 450 km²
- Intensive agro-ecosystem
- Conventional 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 (Qiao et al. 2005)

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

Characterization of bee and plant communities

- Community Weighted Mean trait (CWM) (Qiao et al. 2004)
- Community Weighted Variance (CWV)
- Multi-trait functional diversity (FDs) (Callieri & Legendre 2020)

Statistical analyses

- Morphological space, occupied by all individuals belonging to a grassland, was estimated using the f-hypervolume package (Blonder et al. 2014)
- Linear models included:
  - Local community baseline (flower size, CWM/Tongue length, CWM/Tongue width, CWV bee dependence)
  - Landscape factors (% crop, % grassland, % wood)
  - Local factors: (age of the grassland)
  - Covariables: (age, environmental climate change, number of mowing event, Tree-shaped size at mowing event)
- Best model selected with the Maximum Likelihood test and Akaike information criteria
- Null model approach for examining the possible reduction of trait ranges in grasslands.

- We used the fitd package (Testeau & deleuze 2021) and the community-wide variance relative to the local variance of the regional pool (EC/Rm) (Stede et al. 2012)

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 (Schmidbauer & Ellner 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.