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

Gaëtane Le Provost, Cyrille Violle, Isabelle Badenhausser, Marie d'Ottavio, Nicolas Gross

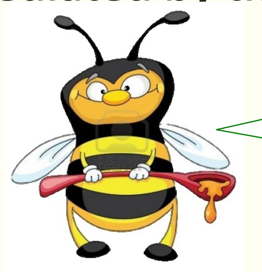
How local plant community and landscape context affect the morphological space of wild bee communities in grasslands ?

Gaëtane Le Provost[1], Cyrille Violle[2], Isabelle Badenhausser[13], Marie D'Ottavio[1], Nicolas Gross[13]
contact: gaetane.leprovost@cebc.cnrs.fr

[1]CNRS–Université de La Rochelle, UMR7372, Station d'Ecologie de Chizé-La Rochelle, Villiers en Bois, F-79360, Beauvoir sur Niort, France
[2]CNRS, UMR5175, Centre d'Ecologie Fonctionnelle et Evolutive, Montpellier, F-34090, France
[3]INRA, USC1339, Station d'Ecologie de Chizé-La Rochelle, Villiers en Bois, F-79360, Beauvoir sur Niort, France

General context

- **Growing concern about wild pollinator loss and the consequences for pollination service** in intensive agricultural landscapes *(eg. Biesmeijer et al. 2006, Deguines et al. 2014, Potts et al. 2010)*
- **Land-use intensification affects wild bee communities through habitat loss and fragmentation at the landscape scale** *(Bommarco 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, Kassen 2002, Murray, Kulhmann & Potts 2009)*

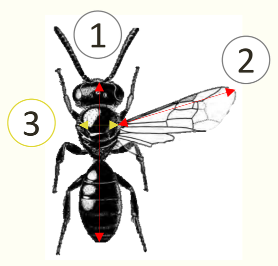


Large diet niche
+ Good dispersal abilities
= Maintained in disturbed landscapes

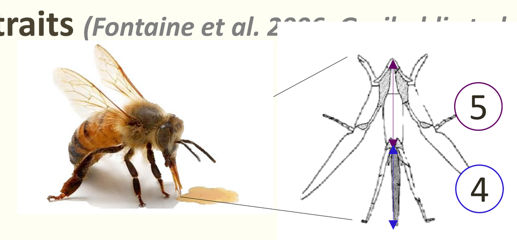
Narrow diet niche
+ Low dispersal abilities
= Not maintained in disturbed landscapes

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

- **Body size and dispersal traits** *(Greenleaf et al. 2007)*:
  1. Body length
  2. Wing length
  3. Distance between wing bases (Inter-Tegular Distance)



- **Resource acquisition traits** *(Fontaine et al. 2006, ... 2015)*:
  4. Tongue length
  5. Prementum length



- **Co-variation among wild bee morphological traits (PCA)**

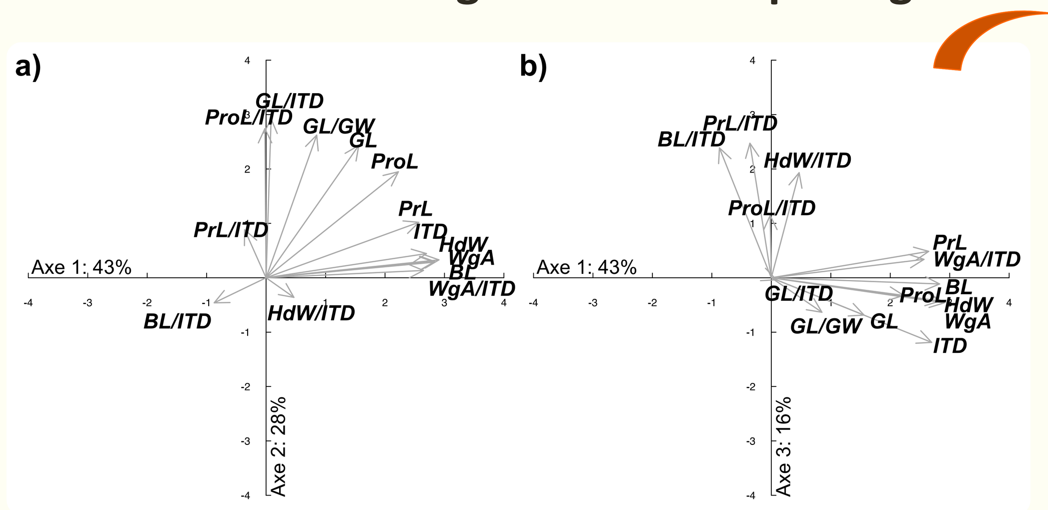


Fig. 1. Co-variation of wild bees morphological traits along 3 PCA axes. % of explained variance from axis 1 to 3 are 43%, 28% and 16% respectively, total variance explained 87%. Trait abbreviations: ITD, Inter-tegular distance (mm²); BL, Body length (mm); WgA, Wing area (mm²); HdW, Head width (mm); GL, Glossa length (mm); PrL, Prementum length (mm); ProL, Probocis length (mm).

- **Traits covariate along three axis:**
  - Axis 1: Body-size and dispersal traits
  - Axis 2: Tongue length and ressource acquisition traits
  - Axis 3: Prementum length and body shape traits
- **In the subsequent analysis, we considered three independant traits:**
  3. Inter-tegular distance (ITD), related to dispersal abilities
  4. Allometric ratio between tongue length and body size
  5. Allometric ratio between prementum length and body size

Material & methods

Study area

- 450 km²
- Intensive agro-ecosystem
- Contrasted landscapes
- Sown and permanent grasslands

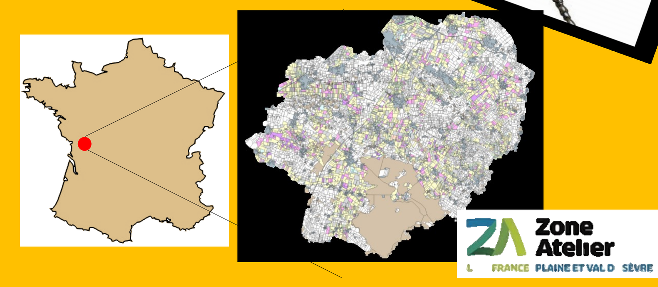


Fig. 2. The study area LTER ZA PVS

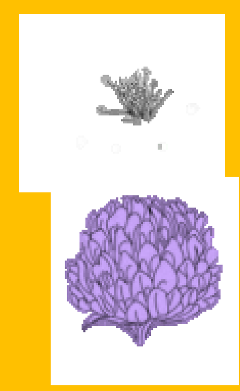
In August 2014, 40 grasslands sampled

- 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 Biolflor *(Klotz et al. 2002)*



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

Characterization of bee and plant communities

- Community Weighted Mean trait (CWM) *(Violle et al 2007)*
- Community Weighted Variance (CWV)
- Multi-trait functional diversity (FDis) *(Laliberté & Legendre 2010)*

Statistical analyses

- **Morphological space**, occupied by all individuals belonging to a grassland, was estimated by using the R *hypervolume* package *(Blonder et al 2014)*
- **Linear models included:**
  - Local plant community factors (Flower Fdis, CWM flowering begin, CWM flowering end, CWM bee dependence)
  - Landscape factors (% crop, % grasslands, % wood)
  - Local factors (Age of the grassland)
  - Covariables (Agri-Environmental Scheme contract, Number of mowing even, Time elapsed since last mowing event)
- **Best model selected** with the Maximum likelihood test and Akaike information criterion
- **Null model approach** for examining the possible reduction of trait ranges in grasslands. We used the R *cati* package *(Taudière & Violle 2015)* and the community-wide variance relative to the local variance of the regional pool (IC/IR) *(Violle et al. 2012)*

Results and discussion

1. Trait by trait (CWM and CWV)

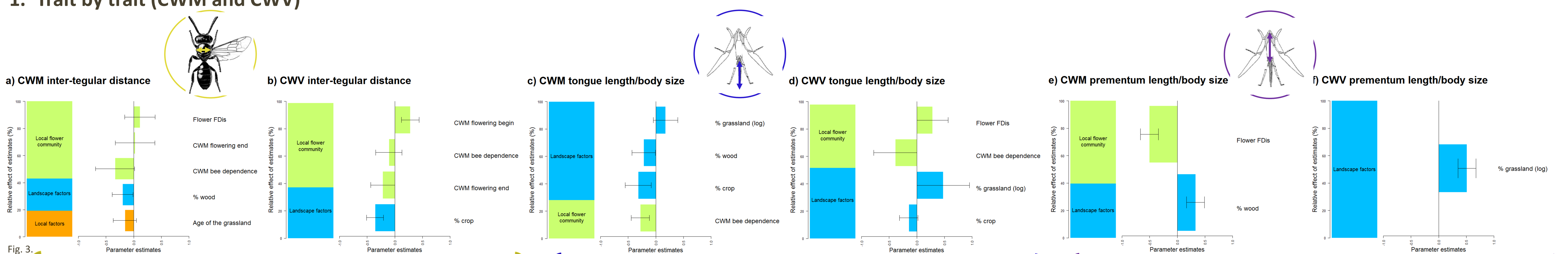


Fig. 3.

- 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 *(Greenleaf et al. 2007, Wright, Roberts & Collins 2015)* and diversity of dispersal traits will be lower in the focal grassland.
- No significant effect on the CWM.

- In landscapes with a high proportion of grasslands, diversity of traits related to resource acquisition is higher. Through a mass-effect dynamic, grasslands can provide spillover of individuals with diverse tongue length to nearby grasslands *(Greenleaf et al. 2007, Wright, Roberts & Collins 2015).*
- No significant effect on the CWM.

- In grasslands with high flower diversity, wild bees tended to have smaller prementum. Species with small prementum may be dependant of flower with high nectar accessibility. Thus, high ressource 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 grasslands.

2. Morphological space (hypervolume)

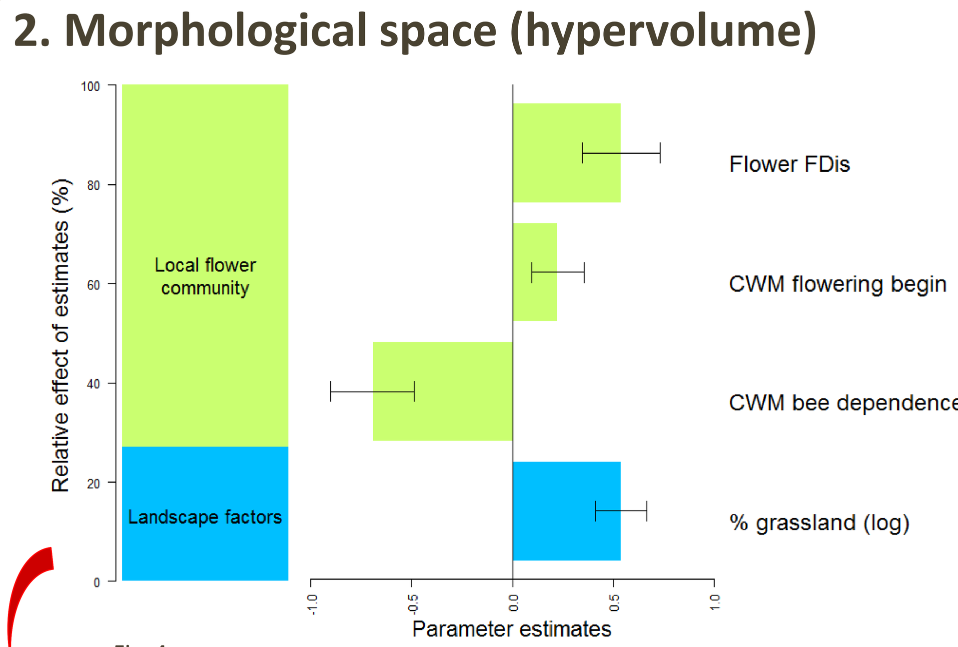


Fig. 4.

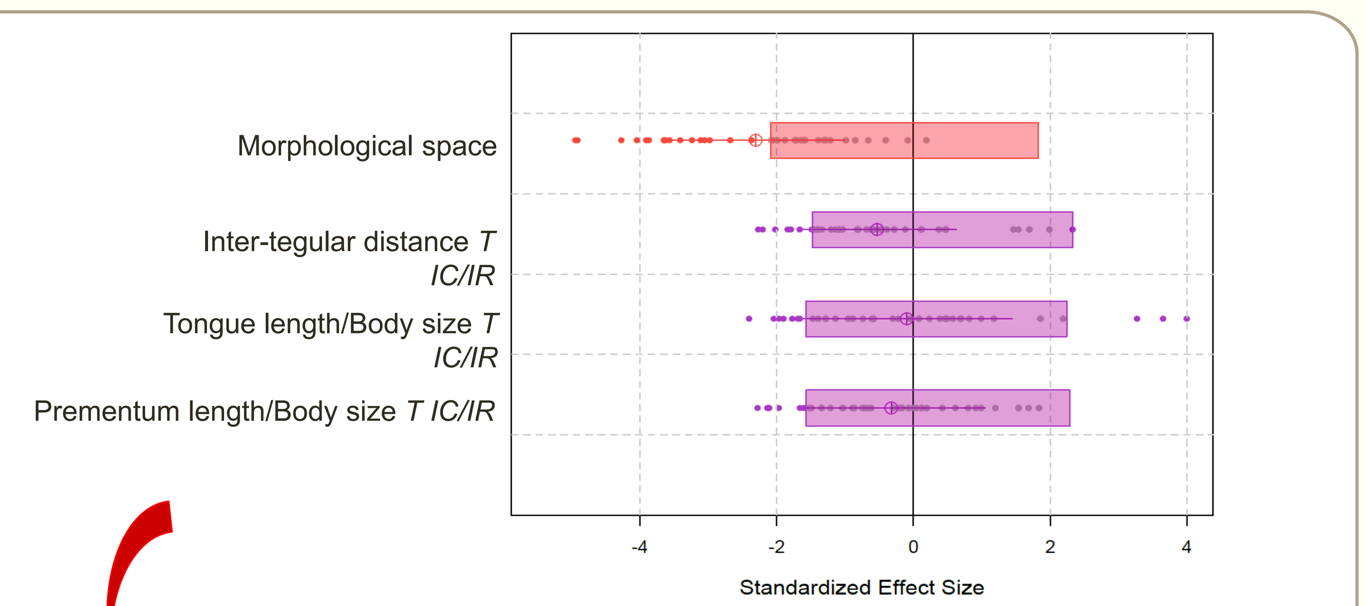


Fig. 5. Standardized effect size (SES) of the hypervolume and the T-statistics for the community-wide variance relative to the total variance in the regional pool (T IC/IR), for the three traits. Red and purple colored dot represents the SES value for one community when it is different from the null model. The mean of the SES (crossed circle) is significantly different from the null distribution if not embedded within the colored zones which represent the null model envelop at 95%.

- In landscapes with high proportion of grasslands, 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.

- About 50% of the grasslands tended to have smaller morphological space thant expected by chance, which suggests an external environmental filtering *(Violle et al. 2012)*.
- No detection of habitat filtering when the three traits are considered separately

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 *(Schmida & 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.

Centre d'Études Biologiques de Chizé · CNRS · PRES Limousin Poitou-Charentes · Région Poitou Charentes · Deux-Sèvres Conseil Général · Université La Rochelle · INRA Science & Impact