A multiscale landscape genetics analytical framework to identify local adaptive variation in the Buckler Mustard

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• Study Area at « Les Rochers-de-Naye »

• Plant: *Biscutella Laevigata* (Brassicaceae)

• 266 AFLP markers sequenced for 361 individuals
Why this case study?

The Buckler Mustard

- Autotetraploid
- Rare alpine plant

Study zone

- Grows only on the ridge
- Local scale adaptation of an isolated population (Parisod & Christin, 2008)

Environmental variables

- A local scale requires high resolution variables - Digital Elevation Model (DEM)
- Dense sampling scheme of temperature and humidity loggers
Goals:

• Explore correlations between genetic markers of *B. laevigata* and environmental variables, exclusively derived from DEMs, to detect potential signatures of natural selection.

• Observe spatial resolution influence’s on association models.

• Analyze signal strength for local models (GWR and sub-populations).
Very High Resolution Digital Elevation Model (VHR DEM) : 0,5m
Variables computed in SAGA GIS (Böhner & Selige, 2006)

- Free and open source GIS software made for geoscientists
- Helped by RSAGA package in R

Visualisation in Quantum GIS

- Free, open source and easy-to-use GIS software
- Python Plug-ins
Adaptive landscape genetics

Identify alleles correlated with environmental variation

Spatial coïncidence (Goodchild, 1996)

Logistic regression in SamBada (Spatial Analysis Method) (Joost et al, 2007)
DEM (0.5m)
Variables selected

- Aspect (Asp)
- Slope (Slo)
- Horizontal and Vertical curvature (Hcu – Vcu)
- Downslope Distance Gradient (DDG) (Hjerdt et al., 2004)
Variables selected

- Morphometric Protection Index (MPI)

- Sky View Factor (SVF)

- Vector Ruggedness Measure (VRM) (Sappington et al., 2007)
Variables selected

- Total Insolation in April (TI4)
- Total Insolation in June (TI6)
- Terrain Wetness Index (TWI) (Sørensen et al., 2006)

\[
WI = \ln \left( \frac{\text{Catchment area}}{\tan(DDG)} \right)
\]
But at which resolution?
Multiresolution computation using a spline (0.5m and 1m:32m by steps of 1m)
Distance to the ridge
70 significant (α=0.01 with Bonferroni correction) associations for 16 markers (6%)

20 firsts with VRM, Hcu, TI4, TI6, Aspect
fuzzy c-means clustering. Threshold of 0.75. 36 individuals are hybrids, 133 in group 1 and 193 in group 2.
No significant associations for G1.
Group 2 gives much more interesting results with 67 associations. 12 markers showed association with at least one variable (VRM, Slo, Vcu then Asp, TI4).
**Geographically Weighted Regression** (Brunsdon, 1996; Nakaya, 2005)

- Analysis of spatially varying relationships
- Build local models, more weight is given to close neighbors.
- Lowers spatial autocorrelation between residuals.

![Fixed Gaussian Kernel](image1)

![Adaptive Gaussian Kernel](image2)
Example of GWR

Legend
- Predicted prevalence of C2b308
  - 0.0141 - 0.0348
  - 0.0348 - 0.1119
  - 0.1119 - 0.2085
  - 0.2085 - 0.3549
  - 0.3549 - 0.4773
  - 0.4773 - 0.6403
  - 0.6403 - 0.8042
- Presence of marker C2b308
- Vector Ruggedness Measure (8m)
  - Blue: 9.23765e-05
  - Light Blue: 0.245912
  - Yellow: 0.491732
  - Red: 0.737551
Temperature and humidity loggers (100 at and between sampling locations)
Next: Comparison with other approaches

GWR, Bivariate LISA

PCAdapt

LFMM, Bayenv

BayeScan

Results from another project on empiric and simulated datasets show:

- high amount of false positives from correlative approaches (GLM, GEE, GLMM)
- common detection of several markers in correlative and population genetic approaches