

Long-distance seed dispersal may blur ecotypic divergence in a terrestrial orchid

Long-distance dispersal & adaptive divergence

The family Orchidaceae is well known for its exceptional diversity, with approximately 26 000 species. It is argued that realized **long-distance dispersal (LDD)** combined with **local adaptation** to different environments is a possible mechanism underlying this species diversity (e.g. Phillips et al. 2012). However, empirical data about LDD combined with local adaptation are scarce and completely lacking for orchids.

Fen orchid

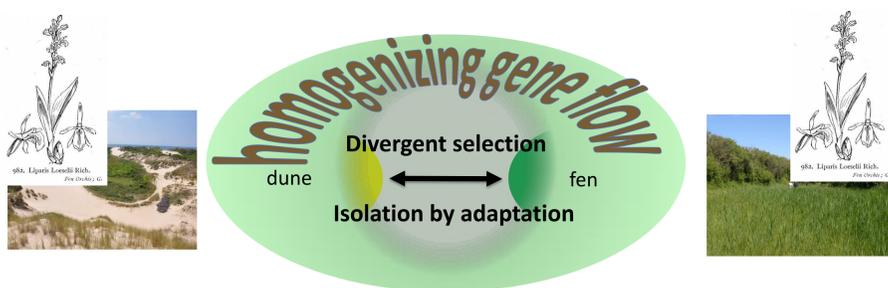
We studied realized LDD and adaptive divergence in fen orchid (*Liparis loeselii* (L.) Rich.), a small green-flowered orchid of fens and dune systems. Two varieties are sometimes distinguished: a narrow-leaved variety occurring in fens, and a shorter, broader-leaved variety (var. *ovata* Ridd. ex Godfery) occurring in dune slacks (Wheeler et al, 1998). **Genetic differentiation may exist between the two habitats** to the extent that hybrid offspring suffers from marked outbreeding depression, i.e. **isolation-by-adaptation**.

Low signals of adaptive divergence

Six (1.3%) ‘outlier’ loci, potentially reflecting local adaptation to habitat-type, were identified with high statistical support. Of these, **only one** (0.22%) was an **outlier** in multiple independent dune-fen population comparisons and thus **possibly reflecting truly parallel divergence**. Signals of adaptation in response to habitat type were most evident at the scale of individual populations.

“Contrasting the expectations, we found remarkably high levels of effective long-distance seed dispersal and low levels of adaptive divergence.”

The homogenizing effect of realized long-distance seed dispersal may overwhelm divergent selection associated to habitat type in fen orchids in Northwest Europe.”



“We expected that different habitats would contribute to strong divergence and restricted gene flow resulting in isolation-by-adaptation.”

High levels of long-distance dispersal

Our results suggest remarkably high levels of **between-population dispersal (15%)** with **dispersal distances up to 220 km**. Populations were admixed and gene flow frequently occurred between populations occupying different habitats. We observed no significant relationship between genetic and geographic distance and a low genetic differentiation among populations ($F_{ST} = 0.09$, $\Phi_{PT} = 0.13$).

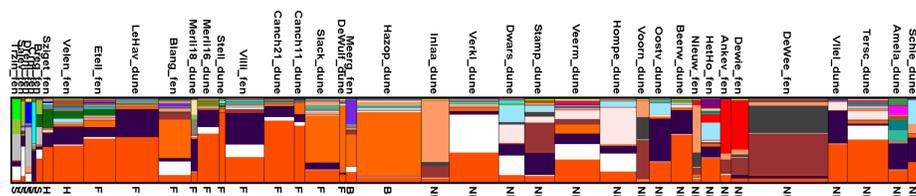


Fig. 1 Graphical representation of the assignment for 38 populations of *Liparis loeselii*, calculated by a Bayesian clustering approach implemented in INSTRUCT based on AFLPs and assuming $K = 28$, suggesting high admixture.

Methodology

We analyzed 451 polymorphic AFLP-loci on a total of 422 individuals from 23 dune and 16 fen populations. Assignment tests were performed with AFLPOP within two independent sites in which we are quite certain to have allocated all fen orchid populations: A) Northwest France and B) Belgium and the Netherlands (Fig. 2). Furthermore, we sampled one population in the French Alps in the Marsh of Les Etelles, five populations in Slovenia located in the pre-alpine hills and north-western Dinaric Mountains, and two populations in Hungary.

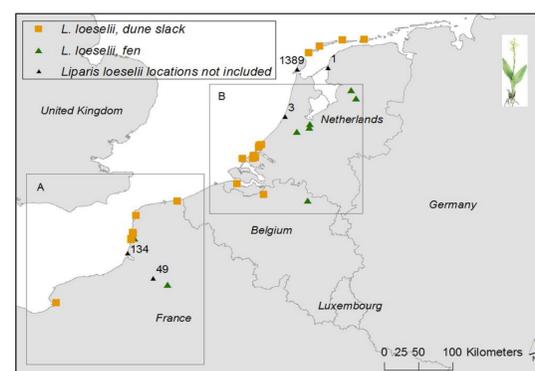


Fig. 2. Locations of *Liparis loeselii* along the coast of the North sea over a distance of 600 km from Normandy in northern France up to the Dutch Wadden Sea islands in the north of the Netherlands. All known locations, except the ones indicated with a black triangle, are included in this study.

Adaptive divergence was investigated by a genome scan approach at different spatial scales (continental, landscape and regional) with the programs BAYESCAN and MCHEZA.

References

- Wheeler et al. (1998). *Bot. J. Linn. Soci.* **126**(1-2): 141-158.
Phillips RD et al. (2012). *Mol. Ecol.* **21**(21): 5208-5220.

Author affiliations

*Research Institute for Nature and Forest (INBO), Brussels, Belgium, ** Instituut voor Biodiversiteit en Ecosysteem Dynamica (IBED), Universiteit van Amsterdam, The Netherlands, ‡Conservatoire Botanique National de Bailleul, France, ++Slovenian Forestry Institute, Slovenia, +Botanical Society of Slovenia, Slovenia Zalaegerszeg Várberki u. 13, H-8900 Hungary