Evolving inversions: The genomic architecture of parallel snail ecotypes

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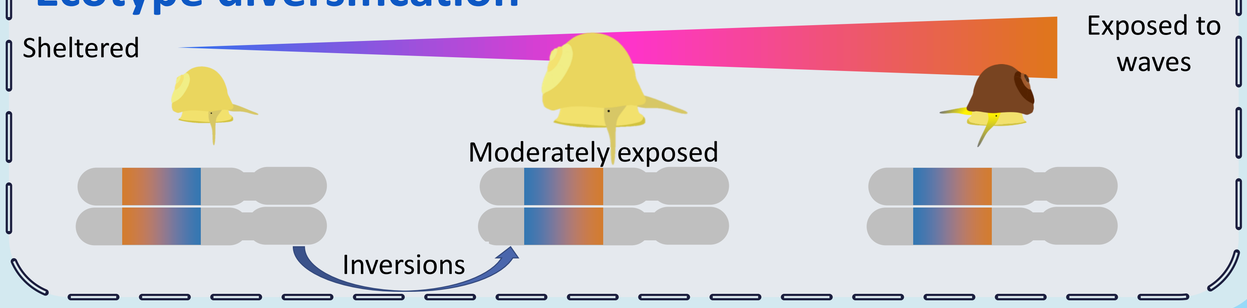
Introduction

Structural Variants (SVs) that reduce recombination in heterokaryotype individuals have been shown to **facilitate local adaptation** by sheltering locally favourable genetic variants from gene flow. **Hybrid zones established along environmental gradients provide a particularly powerful setup to study the role of SVs in local adaptation and ecological isolation**, but with the limit that other reproductive barriers may coincide with environmental transitions. Thus, disentangling the role of SVs in local adaptation from different types of barriers to gene exchange remains a major challenge. One way to address this issue is to **establish links between the genomic variation and the phenotypic traits involved in ecological adaptation** in an attempt to **identify genomic regions containing barrier loci**, and the **selective forces involved**. This approach should be particularly relevant when **repeated across independent environmental gradients**, as it may reveal **differences in how SVs influence the evolution of ecotypes**.

Littorina fabalis

- Intertidal gastropods
- North-Western distribution in Europe
- Locally adapted ecotypes
- Direct development/low dispersal

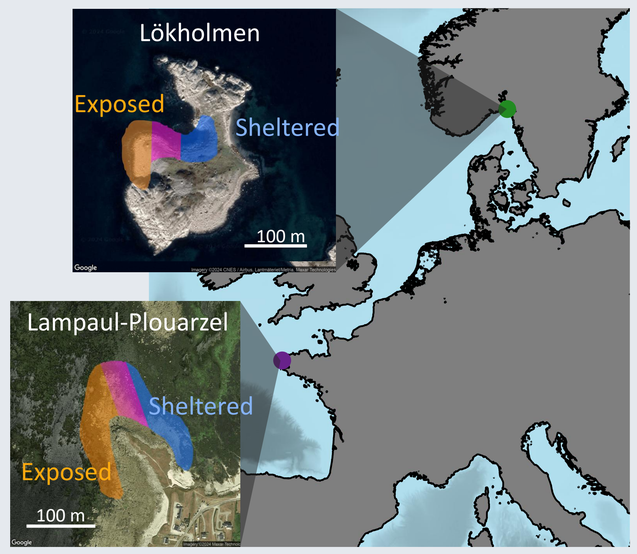
Ecotype diversification



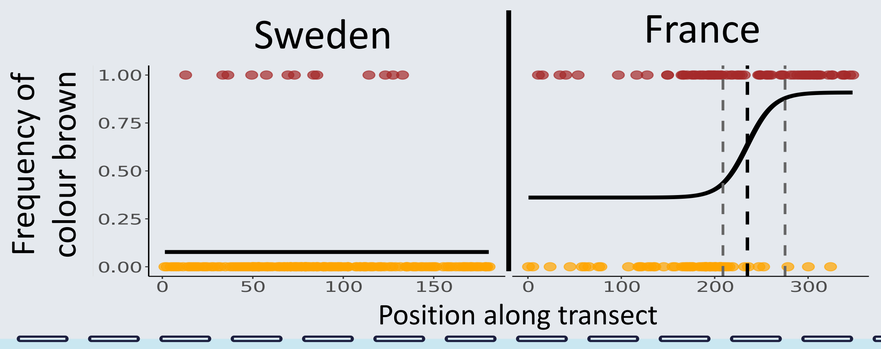
Materials and Results

Sampling

- Two transects
- Sampling from sheltered to exposed habitats
- 150 individuals per transect
- Whole Genome Sequencing
- 506,610 unlinked SNPs

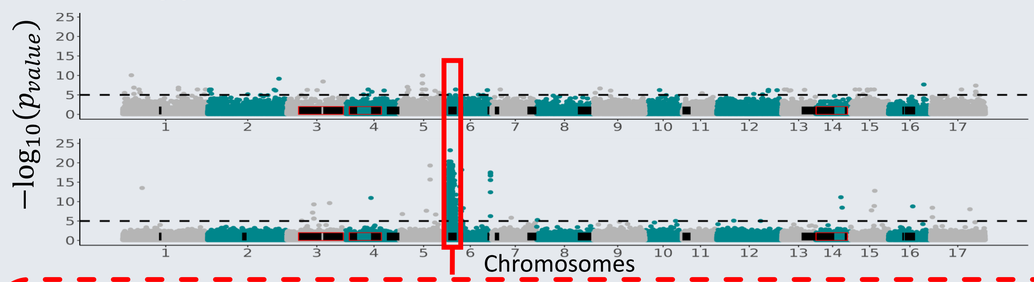


Phenotypic variation



- Shell **colour variation** mainly in **France**

Phenotypic association

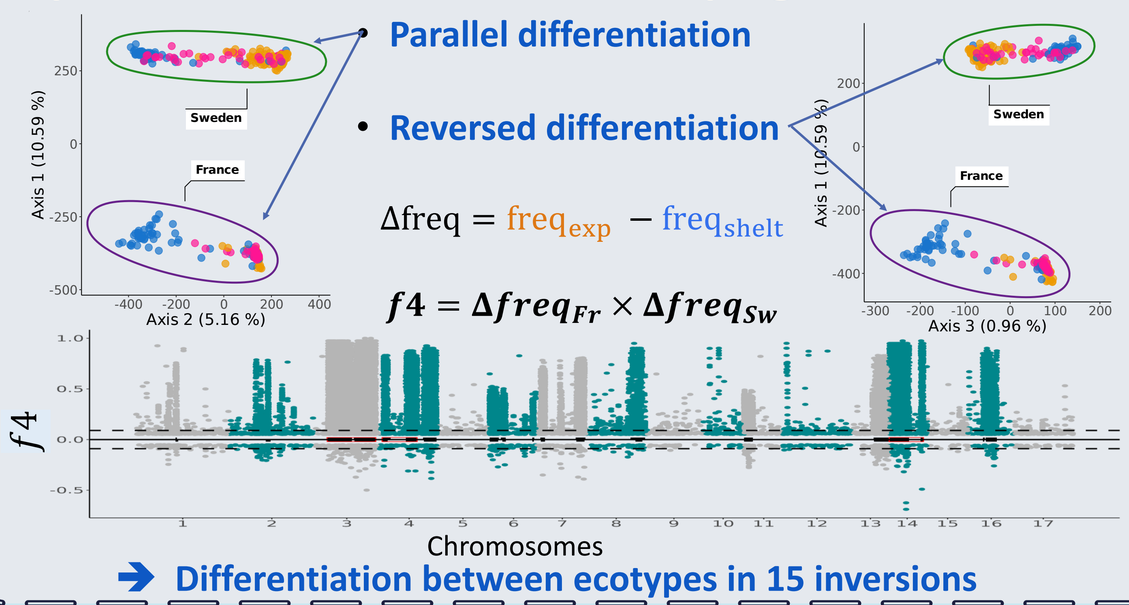


Population structure and landscape genomics

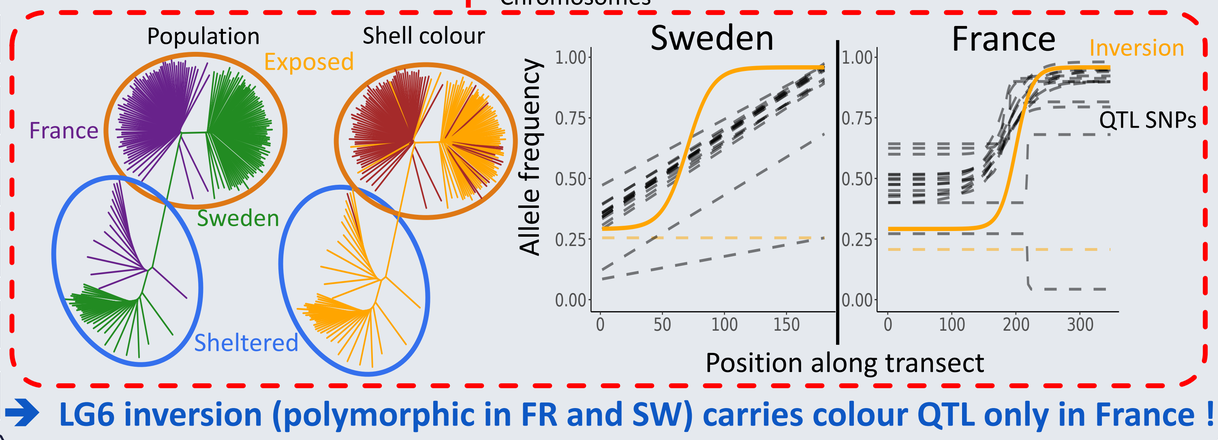
- **Parallel differentiation**
- **Reversed differentiation**

$$\Delta\text{freq} = \text{freq}_{\text{exp}} - \text{freq}_{\text{shelt}}$$

$$f4 = \Delta freq_{Fr} \times \Delta freq_{Sw}$$



➔ **Differentiation between ecotypes in 15 inversions**



➔ **LG6 inversion (polymorphic in FR and SW) carries colour QTL only in France !**

Conclusion

This study shows that the two pairs of ***L. fabalis* ecotypes** observed along Swedish and French shores share **extensive genetic differences repeatedly associated with the wave exposure gradient**. These **parallel differences** between ecotypes are mainly located within **15 high-differentiation genomic regions** that display signatures expected from **chromosomal inversions**. However, even if this parallelism is strong, the content of the inversions shows **key differences between the two studied hybrid zones**. Notably, the LG6 island, that is polymorphic is both transects, carries a colour QTL only in France. Overall, this study demonstrates that while **chromosomal inversions can repeatedly establish clines in response to similar environmental gradients, they may also carry region-specific traits** that contribute to local morphological adaptation, as observed with shell colour differences between sites.