Incipient local adaptation to heavy metal pollution in a mycorrhizal fungus

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Local Adaptation

- Organisms match their environment
- Genomic signatures of selection highly differentiated genomic region

http://www.icr.org
Local Adaptation

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[Image of moths with white and black wings]

http://www.icr.org
Polygenic Local Adaptation

• Organisms match their environment

• Signatures of selection diffuse across genome

• The more genes are contributing to the adaptation, the more modest their contribution
Fungus *Suillus luteus*

- Mutualistic partner of pine
- Provides water and nutrients and receives carbohydrates in return

Photo by Noah Siegel

Photo by Laura Coninx
Heavy Metal Pollution

- Recent (~150 yrs) zinc smelter polluted areas in Belgium
- Zinc and Cadmium
- Heavy metals cause oxidative stress
S. luteus shows variable Zn tolerance

- Zn-tolerant isolates grow more in high Zn and accumulate less metal

ZINC TOLERANT

ZINC SENSITIVE

0.1 mM  3.06 mM  12.2 mM

Mycelial Zn (mg/g DW)

ZINC TOLERANT
ZINC SENSITIVE

(Colpaert et al. 2011)
Questions

Is heavy metal tolerance in *S. luteus* a polygenic trait?

What are the main targets of selection?
Sequenced 38 whole genomes [JGI CPS #1776]

20 from polluted soil
18 from unpolluted soil

Compiled SNP markers across the genomes
Absence of population structure

Shared genetic variation across polluted and unpolluted soils

Genetic differences between isolates from polluted and unpolluted soils should be regions of the genome under selection
Allelic differentiation

Low divergence across genome

No distinct divergence peak
Allelic differentiation in transporters

Gene ontology enrichment analyses on top 5% Fst windows

Fst across 5kb windows
Copy number variation on transporters

Gene ontology enrichment analyses on top 5% Vst windows

- Organic acid transmembrane transporter activity (26.77%)
- Amino acid transmembrane transport (11.81%)
- Translation initiation factor activity (13.39%)
- Translational initiation (18.9%)
- Protein kinase activity (11.02%)
- Translation (7.09%)
- Other

Gene copy number variation across 250bp windows
Transporters under selection

Transporters allow movement of ions across membranes

Image from: https://themedicalbiochemistrypage.org/membranes.php
Heavy metal adaptation in *S. luteus*

- (1) Selection on the population is likely polygenic
- (2) The main targets of selection are trans-membrane transporters
Candidate genes underlying tolerance

- Transporters
- Metal ion binding (chelation)
- Antioxidants
Acknowledgements

Suillus International Consortium

Sara Branco
Hui-Ling Liao
Joske Ruytinx
Jan Colpaert
Nhu Nguyen
Peter Kennedy
Tom Bruns
Rytas Vilgalys
Yi-Hong Ke
Laura Coninx