Thermal plasticity of the kelp *Laminaria digitata*

Daniel Liesner
Phylogeographic history

Speciation in Atlantic
~5.3 mio yrs BP after opening of Bering strait

Rothman et al. (2017). A phylogeographic investigation of the genus Laminaria ... J Phycol
Starko et al. (2019). A comprehensive kelp phylogeny sheds light on the evolution ... Mol Phylogenetics Evol.
Phylogeographic history


Raybaud et al. (2013). Decline in Kelp in West Europe and Climate. PLoS ONE

Global warming leads to range shifts of kelp forests.
Marine heatwaves


Marine heatwave frequency

Marine heatwaves threaten trailing edge kelp populations.

Wernberg et al. (2016). Climate-driven regime shift of a temperate marine ecosystem. Science
Local adaptation in *L. digitata*

Local thermal adaptation between central and trailing edge populations.

King et al. (2019). Evidence for different thermal ecotypes in range centre and trailing edge ... JEMBE
Local plasticity for heat tolerance?

Do populations of *Laminaria digitata* differ in short-term heat tolerance?

Can population genetic characteristics be connected to physiological responses?
Sampling locations

- Spitsbergen
- Tromsø
- Bodø
- Helgoland
- Roscoff
- Quiberon

Locations marked on the map include:
- SPT
- TRO
- BOD
- HLG
- ROS
- QUI
Experimental design

$n=30$

Physiology and population genetics
Two clades of *L. digitata*

Northern and southern clade
Two isolated populations

F_{IS}: 0.13 ± 0.05 *
N_e: 17 ± 4
AR: 3.5 ± 0.4
H_e: 0.44 ± 0.07

F_{IS}: 0.04 ± 0.03
N_e: 120 ± 4
AR: 2.6 ± 0.4
H_e: 0.31 ± 0.08

Inbreeding in SPT, Differentiation in HLG?
Recovery

5 days at 23°C harmful for all populations.
Synthesis: local plasticity

- Fixed thermal limits
- Northern and southern clades
- Subtle differentiation in marginal populations
Loss of southern refugia & dispersal of “northern“ genotypes?

The special case of Helgoland

Future loss of this and other “southern” populations?

Bartsch et al. (2013). Prevailing sea surface temperatures inhibit summer reproduction … J Phycol
Transgenerational plasticity

TGP: interactive effects of parental and offspring environment on offspring phenotype

Adaptive TGP: beneficial parental effects in predictable environments

Prevalence of TGP

Salinas et al. (2013). Non-genetic inheritance and changing environments. Non-Genetic Inheritance
TGP in macroalgae?

Does adaptive TGP prime kelp offspring for higher temperatures across life cycle stages?
Kelp life cycle

Adapted from Biological Science by Freeman. © 2008 Pearson Education, Inc.
Hypothesis: Adaptive TGP for parental gametogenesis temperature.

5 genetic lines

5 °C 15 °C

Gametogenesis

F0

Rearing

F1

Experiment
Field material: Reaction norm

Field meristems grow faster at 15 °C

Mean ± SD, n=20

TGP experiment
TGP: Growth

Mean ± SD, $n=4$ for 5 genetic lines

Gametogenesis temp. [°C]

Rearing temp [°C]

Length [normalized]

-4 -2 0 2 4

G5 G15 G5 G15

E5 E15

Exp. temp. [°C]

TGP: Beneficial effect of 5 °C gametogenesis on growth.
TGP: Beneficial growth effects following cold parental treatment. No adaptive TGP regarding warm temperature.
Relevance

Helgoland mean SST 2017-18

Sporophytes [cm⁻²]

Importance of cold refugia during winter!

Bartsch et al. (2013). Prevailing sea surface temperatures inhibit summer reproduction of the ... J. Phycol.
Conclusion

*Laminaria digitata* thermal response

1. Fixed thermal limits with slight local differentiation

2. TGP in favour of cold reproduction
Thank you!

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