Response of algal holobionts towards environmental changes

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The holobiont concept: a « new » paradigm in biology

Macroagal biofilms - a second skin

Brown macroalgae: Key components of marine coastal ecosystems that depend on their biofilm

Sugars, Amino acids

Egan et al. 2013

Vitamins, NH₄, hormones defense
Macroalgal biofilms - a second skin

Brown macroalgae: Key components of marine coastal ecosystems that depend on their biofilm

What is the role of the biofilm in this?

Global decline

Egan et al. 2013

Sugars, Amino acids

Vitamins, NH₄, hormones defense

Araujo et al. 2016

[Map showing presence and reduction]
Environmental changes cause impact holobiont systems

- Global warming
- Pollution
- Ocean acidification

Holobionts: an important concept....
Environmental changes impact holobiont systems

Global warming
Pollution
Ocean acidification

Holobionts: an important concept....
...but it adds a lot of complexity
Example: Temperature increase can induce virulence in symbiotic bacteria

*Delisea pulchra + Ruegeria sp. R11*

Case et al. 2011

Furanones ++

Bleaching and virulence
Example: Temperature increase can induce virulence in symbiotic bacteria

*Delisea pulchra + Ruegeria sp. R11*

Case et al. 2011

Furanones ++

Bleaching and virulence

The challenge:

1 bacterium → many bacteria

1 metabolite → many metabolites
A good laboratory model is required: *Ectocarpus*

- Sister group to Kelps
  (Silberfeld et al. 2010)

A small but active community and many tools
(Cock et al. 2010, Prigent et al. 2015, ...)

- Collection of > 500 *Ectocarpus*-derived bacteria
  (Tapia et al. 2016;
  KleinJan et al. in revision;
  Dittami et al. in prep.)
Question 1: Which bacteria are beneficial in stable conditions? **metabolic complementarities?**

- Vitamins, NH₄, hormones, (defense compounds)
- Sugars, Amino acids

**Using metabolic networks to predict complementarities**

 encodes Enzymes catalyzes Reactions

A + B -> C

Genome

Metabolic networks

DyLiSS
From metabolic networks to metabolic complementarities

Dittami, Eveillard, Tonon 2014

β-alanine

Vitamin B5 (both)

Coenzyme A (both)

Pantoate

Enumerate complementarities / exchanges: Answer set programming-based approach

Holobiont metabolism
Defining complementary communities and testing predictions

Predict more or less beneficial holobiont communities

In vitro testing of predictions

Growth, produced metabolites

Frioux et al. 2018
Promising preliminary results

Algal growth rate

+ bacteria

control

Compounds characterized by UPC²-QTOF after 4 weeks of coculture. (-): absence (+): presence

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M2 Bertille
Burgunter-Delamare

But: problems controlling the bacterial community
Question 2: Plasticity of metabolic interactions under environmental stress

Impact of microbiome on temperature tolerance?

Changes in community?

Induction of virulence?

Impact on potentially beneficial exchanges?

Co-cultures

Ongoing work: Elham Karimi
The role of the microbiome during low salinity acclimation

_Ectocarpus subulatus_ freshwater strain:
- The only known freshwater _Ectocarpus_
- One of only max. 8 brown algal species found in fresh water

Hopkins River Falls, Victoria, Australia

Growth in freshwater depends on bacteria.

→ Despite extensive efforts and test with cultured bacteria the identity of the microbiome for fresh water tolerance remains unknown

**UNCULTIVABLE MICROBIOME!**
Working with modified microbiomes

Bacterial community

- ATBmix
- ATBmix 2
- ATBmix 3

«Full microbiome »

Study response to freshwater with multi «omics» approach:
- Genome
- Transcriptome
- Metabolome
- Metabolic networks for data integration

Generate hypotheses:
- ↓ Vitamin K1 synthesis
- ↓ Seleno-amino acid biosynthesis
- ↑ Autoinducer AI-1 biosynthesis (Virulence?)
Question 3: Environmental relevance of laboratory results: the example of *Saccharina latissima*

interactions, markers methodology

experimental system to test new hypotheses

Thesis Bertille Burgunter-Delamare (2018-2021)
Conclusion: biology is messy and slow

• (and biologists too, sometimes)

But: don’t give up...
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Thank you