Effect of heat stress on fecal microbiota composition in swine

Le Sciellour M.\textsuperscript{1}, Hochu I.\textsuperscript{2}, Zemb O.\textsuperscript{2}, Riquet J.\textsuperscript{2}, Gilbert H.\textsuperscript{2}, Giorgi M.\textsuperscript{3}, Billon Y.\textsuperscript{4}, Gourdine J.-L.\textsuperscript{5}, Renaudeau D.\textsuperscript{1}\textsuperscript{*}

\textsuperscript{1}PEGASE, INRA, Agrocampus-Ouest, 35042, RENNES, France
\textsuperscript{2}GenPhySE, Université de Toulouse, INRA, INPT, ENV'T, 31320, Castanet Tolosan, France
\textsuperscript{3}PTEA, INRA, 97170 Petit-Bourg, France
\textsuperscript{4}GenESI, INRA, 17700 Surgères, France
\textsuperscript{5}URZ, INRA, 97170 Petit-Bourg, France

*Corresponding author: david.renaudeau@inra.fr
Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Context and objectives

Context

- Host
- Performances
- Environmental perturbations
  - Ambient temperature elevation
  - Sanitary problems
  - ...

Host

Performances

Environmental perturbations

Ambient temperature elevation
Sanitary problems
...
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Context and objectives

- Heat stress (HS) : main concern for livestock production in many countries
- New methods to improve performances

Context

- Host
- Environmental perturbations
  - Ambient temperature elevation
  - Sanitary problems
  - ...
- Performances
Context and objectives

- Potential role of microbiota in pig metabolism
- Would help the host for better coping with environmental perturbations

Diagram:
- Host
- Microbiota
- Environmental perturbations
  - Ambient temperature elevation
  - Sanitary problems
- Performances...
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Context and objectives

**Context**
- Potential role of microbiota in pig metabolism
- Would help the host for better coping with environmental perturbations

**Objective**
- What is the impact of climate and heat stress on pig gut microbiota?

**Environmental perturbations**
- Ambient temperature elevation
- Sanitary problems
- ...
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Experimental design

- 1,200 pigs raised under temperate or tropical climate
- Cross-bred Large White x Créole

Fecal samples obtained at 23 wk (chronic HS n=600, thermoneutral n=600) and at 26 wk of age (acute HS n=600)

Microbiota analysis: Illumina MiSeq sequencing → Operational Taxonomic Units (OTU)
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Experimental design

- 1,200 pigs raised under temperate or tropical climate
- Cross-bred Large White x Créole

Experimental design:

- Temperature increase effect
  - Thermoneutrality
  - Acute heat stress
  - Chronic heat stress
  - Climate effect
  - Weeks of age: 11, 23, 26
  - Feces obtained at 23 wk (chronic HS n=600, thermoneutral n=600) and at 26 wk of age (acute HS n=600)

Microbiota analysis: Illumina MiSeq sequencing → Operational Taxonomic Units (OTU)
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Statistical pipeline

1,687 samples

1,688 OTUs

OTU table

→ diversity

→ PCA

→ sPLS-DA

Analyses based on 1,688 OTUs

At least 7,000 sequences per sample

- Unsupervised analysis
- Unsupervised analysis
- Supervised analysis
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Results

Diversity

→ No clear diversity difference between the environments

Nb counts

Shannon index

Tropical

W23

Temperate

W26
Results
Principal Component Analysis

PCA (individual plot)
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Results
Principal Component Analysis

Groups according to the environment

Legend
- Thermoneutral
- Acute HS
- Chronic HS

PCA (individual plot)
Results
Principal Component Analysis

1st component: temperature effect

Heat stressed animals

Thermoneutral animals

Legend
- Thermoneutral
- Acute HS
- Chronic HS
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Results
Principal Component Analysis

Principal Component Analysis (individual plot)

2\(_\text{nd}\) component: climate effect

Tropical climate

Temperate climate

Legend
- Green circles: Thermoneutral
- Purple triangles: Acute HS
- Red diamonds: Chronic HS
Feed-a-Gene
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Results
Sparse Partial Least Square Discriminant Analysis

Thermoneutral vs chronic HS

Thermoneutral vs chronic HS highly discriminated using microbial information

Legend
- Thermoneutral
- Chronic HS

Nb OTUs | Cumulative BER
--- | ---
1st component | 36 | 1.7%
1st + 2nd components | 36 + 89 | 0.2%

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Results
Sparse Partial Least Square Discriminant Analysis

Thermoneutral vs acute HS

Legend
- Thermoneutral
- Acute HS

Sparse Partial Least Square Discriminant Analysis

<table>
<thead>
<tr>
<th></th>
<th>Nb OTUs</th>
<th>Cumulative BER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\text{st} component</td>
<td>32</td>
<td>9.3%</td>
</tr>
<tr>
<td>1\text{st} + 2\text{nd} components</td>
<td>32 + 30</td>
<td>7.1%</td>
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</table>

Thermoneutral vs acute HS well discriminated using microbial information
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**Results**
Sparse Partial Least Square Discriminant Analysis

Thermoneutral vs chronic HS

Thermoneutral vs acute HS

Only 5 biomarkers of the « temperature increase » in common

- Only short term temperature increase vs tropical environment (temperature, humidity...)

Sparse Partial Least Square Discriminant Analysis

120

5

57

Prevotellaceae,
Lactobacillaceae,
Peptostreptococcaceae
Conclusions

Microbiota information can be used to discriminate with accuracy:
- Pigs raised under different climate environments
- Pigs exposed to a heat stress

Microbiota composition can be used as biomarker of heat stress exposition in our experimentation

Use of microbiota as a biomarker of the pig adaptation to heat stress?
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Thank you for your attention.
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Results
Sparse Partial Least Square Discriminant Analysis

Acute HS vs chronic HS

<table>
<thead>
<tr>
<th>Component</th>
<th>Nb OTUs</th>
<th>Cumulative BER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st component</td>
<td>16</td>
<td>0.5%</td>
</tr>
<tr>
<td>1st + 2nd components</td>
<td>16 + 19</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

Legend
- Acute HS
- Chronic HS

Climates highly discriminated
Experimental design

Temperature per batch under temperate climate

Ambient temperature (°C)

Batch number

thermoneutral (W11 --> 23)

HS (W23 --> 26)

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