HIGHLIGHTS ON ANIMAL MICROBIOMES

Claire Rogel-Gaillard

Email: claire.rogel-gaillard@inrae.fr
ANIMALS SERVE A WIDE RANGE OF FUNCTIONS TO HUMAN SOCIETIES AND TO THE ENVIRONMENT: FOCUS ON LIVESTOCK

- Livestock
- Models
- Pets
- Wildlife

- Food supply
- Environmental maintenance
- Ecosystemic services
- Work power
- Companions
- Biological models
- Etc.
Living organisms are interacting holobionts in a shared environment - dynamic microbial fluxes

Source: European Commission
The agroecological transition of livestock systems

- Yields
- Growth
- Product quality
- Reproduction capacity
- Resistance to diseases

Main concerns
- Reducing the use of antibiotics and antimicrobials
- Feed efficiency, greenhouse gas emissions
- Promoting health and welfare
- Combining sustainability and competitiveness

Multi-performance: environmental, societal, economical
- Environmental footprint
- Climate change mitigation
- Adaptation to changing environments
- Resistance to disease
- Immune capacity
- Robustness
- Welfare, longevity

Genomes x Microbiomes x Environment x Practices x Socioeconomics

One World - One Health
FOR ANIMALS, THE GUT MICROBIOME OCCUPIES A STRATEGIC POSITION

Trophic and metabolic functions
- Energy expenditure
- Nutrient accessibility
- Short chain fatty acids
- Adiposity
- Vitamins

Intestine functions
- Tissue regeneration
- Gut motility
- Permeability

Connectivity along the axis gut microbiota-brain
- Anxiety
- Pain perception
- Behavior

Immunity functions and protection against pathogens
- Maturation of gut-associated lymphoid tissues (GALT)
- Local and systemic immunity

Intestinal vessel formation

Feed efficiency
Methane

Animal welfare

Immune capacity
Resistance to diseases
THE DIGESTIVE TRACT: SPECIES-SPECIFIC EVOLUTION STRATEGIES

Stevens et al., Physiol. Review, 1998
**Complementary Questions and Approaches**

### Composition and Variability?
- 16S, 18S, 23S
- Shotgun metagenomics
- Reduced sequencing

### Factors Influencing Microbiomes?
- Host genetics
- Feed and feed additives
- Environment
- Age, sex
- Farm practices
- Medication

### Links with Traits of Interest?
- Feed efficiency
- Methane emission
- Behavior and welfare
- Sensitivity to pathogens
- Immune capacity

### Prediction and Diagnostics?
- Microbiability
- Biomarkers

- Gene catalogs
- Host genetics
- Weaning
- Vaccine response
CONSTRUCTION OF GENE CATALOGS

A reference gene catalogue of the pig gut microbiome

2018

The chicken gut metagenome and the modulatory effects of plant-derived benzylisoquinoline alkaloids

2021

Expanded catalog of microbial genes and metagenome-assembled genomes from the pig gut microbiome

Huang et al. Microbiome (2018) 21:2
A catalog of microbial genes from the bovine rumen unveils a specialized and diverse biomass-degrading environment.

Co-abundance analysis reveals hidden players associated with high methane yield phenotype in sheep rumen microbiome.

An integrated gene catalog and over 10,000 metagenome-assembled genomes from the gastrointestinal microbiome of ruminants.

7 ruminant species:
- Dairy cattle
- Water buffalo
- Yak
- Goat
- Sheep
- Roe deer
- Water deer

10 GIT regions:
- Stomach: rumen, reticulum, omasum, abomasum
- Small intestine: duodenum, jejunum, ileum
- Large intestine: cecum, colon, rectum
Gene catalogs of microbiomes tell stories on their host species

Reference resources for functional metagenomics

Xie et al., Microbiome, 2021
EXISTENCE OF ENTEROTYPES

In humans

[Diagram showing enterotypes with Bacteroides, Prevotella, and Ruminococcus]

Qin et al, Nature, 2010

Enterotypes PM
Prevotella
Mitsuokella

Higher body weight

In pigs

[Diagram showing enterotypes with Ruminococcus and Treponema]

Large White pigs (60d)

Enterotypes RT
Ruminococcus
Treponema

Stereotypes About Enterotype: the Old and New Ideas
Mingyue Cheng*, Kang Ning*.

Genomics Proteomics Bioinformatics, 2019

Ramayo-Caldas et al., ISME J 2016
GUT MICROBIOME AND VULNERABILITY AT WEANING: INFLUENCE OF THE AGE AT WEANING IN PIGS

Increased microbial diversity with age at weaning

F. prausnitzii: increased relative abundance with age at weaning

Weaning at 42d: no record of diarrhoea

N = 12 / age; 16S sequencing

Protective effect of Faecalibacterium prausnitzii? Candidate probiotics?
There are predictors of vaccine response levels in the gut microbiota before vaccination (IAV).
- Standardized methods to collect microbiomes on farms, to store and process samples for further analyses; large-scale ring tests would be useful as in humans for comparing protocols.
- Cost of shotgun metagenomics on large animal populations
- Analysis of microbiomes at all body sites (lung, skin, vagina, etc.)
- Availability of effective methods to assess a microbiome diagnosis on farms at individual and population levels
- Data interpretation for optimizing farm practices
Importance of the intervention time windows to efficiently modulate the microbiomes

Microbiomes are genetic resources that contribute to sustainability and need to be preserved

Holobiont: a new paradigm to study animal phenotype construction and plasticity (phenotype-genotype links)

Implementation of hologenomics approaches: G+E+M
HOLOFLUX: HOLOBIONTS AND MICROBIAL FLUX WITHIN AGRIFOOD SYSTEMS

HOLOFLUX : AN INTERDISCIPLINARY METAPROGRAMME AT INRAE

To understand, predict and control the functioning of holobionts and microbiomes as well as their interactions with the environment, in various agronomic contexts, taking into account the issues of sustainable food and health preservation.

https://www6.inrae.fr/holoflux_eng/

SCIENTIFIC AREAS

- Mechanisms underlying assembly and interactions within holobionts
- Microbial flux and dynamics within an agrifood system
- Control and management of microbial fluxes
There is an ISAG standing committee on Animal Microbiomes
An exciting session in preparation!
Thank you for your attention