FBN

LEIBNIZ INSTITUTE
FOR FARM ANIMAL BIOLOGY

Member of Leibniz Association

Nutritional programming of piglet growth and development in the early neonatal period

Dr. Quentin Sciascia and Prof. Dr. Cornelia C. Metges

LEIBNIZ INSTITUTE
FOR FARM ANIMAL BIOLOGY

Ernährungsphysiologie
Oskar Kellner

Member of Leibniz Association

Nutritional Programming

Original definition

Nutritional programming is the process through which variation in the quality or quantity of nutrients consumed **during pregnancy** exerts permanent effects upon the developing fetus[1].

Origin…

The 'developmental origin of health and disease', linking early-life malnutrition (deficiency or excess) to metabolic diseases[2].

1. "Nutritional programming of disease: unravelling the mechanism." Journal of anatomy 215.1 (2009): 36-51.
2. Hales, C. Nicholas, and David JP Barker. "Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis." Diabetologia 35.7 (1992): 595-601.

Nutritional Programming

Updated definition

Nutritional programming is the process through which variation in the quality or quantity of nutrients consumed ***during periods of developmental plasticity*** exerts permanent effects upon the developing organism.

Why is this important?

- Organ development does not stop after birth
- Studies have shown that differences in nutritional experience at critical periods, both pre- and post-natally, can program future development, metabolism and health.

Nutritional Programming

Pigs are a widely utilized species for studying the influence of nutrition on development. ***Why?***

Prolific

Well studied

Good human model

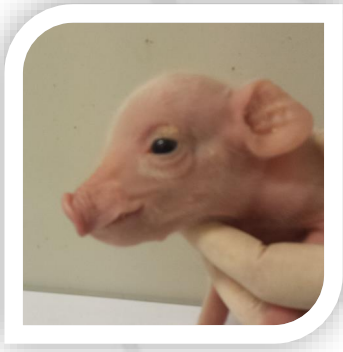
Relatively inexpensive

Farmed species

Monogastric

There has been an increase in the number of fetal growth restricted (FGR) piglets….. ***thus providing an excellent experimental for nutraceutical research!!!***

Nutritional Programming



What is fetal growth restriction (FGR)?

- A condition where the fetus does not reach its growth potential during gestation:
  - Smaller (lower energy reserves)
  - Developmentally and *thus* functionally immature

- This has knock-on effects post birth:
  - Higher mortality / morbidity
  - Those that do survive have a lower growth potential
  - Altered carcass composition
  - Increased rearing costs

Intervention should occur as soon as possible post birth!!

Nutritional Programming

What makes the neonatal period so special?

- Period of high stress
  - ***Nutritional****: switching from placental to enteral nutrition*
  - ***Environmental****: uterine to external, temperature and pathogens*
  - ***Competition:*** *nutrient intake, warmth*
- Period of high mortality – *welfare issue*
- Piglets are still maturing – *organs are still developing (Plasticity)*
- Microbiome colonization
- Immune system maturation begins – *inherited via maternal milk*
- Maternal milk is the sole source of nutrition…. ***but***

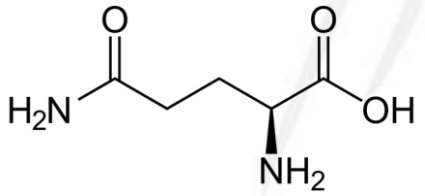
….some dietary components in maternal milk are insufficient for protein accretion in neonatal piglets!!

Nutritional Programming

What has been done? – Maternal Nutrition

- As maternal milk is the sole nutrient source interventions are designed to improve milk composition:

Glutamine / Branched-Chain*



- Improved milk glutamine (gln) concentrations[1,2]
- Improved milk yield / intake[1,2]
- Improved suckling piglet performance[1,2]
- *Gln is a functional amino acid*
- Gln+Glutamate: the most abundant amino acids in sows milk
- AminoGut®
- ***Currently no recommendations for neonatal piglets***

***BCAA – Branched chain amino acids: leucine, isoleucine, and valine**

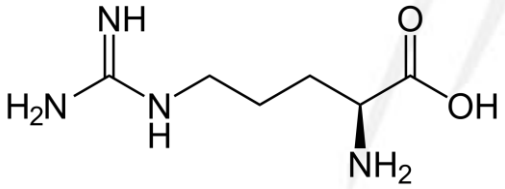
1. Yang, X. F., et al. Annals of Animal Science .ahead-of-print (2018).
2. Rezaei, Reza, et al. (2013): 849-13.

Nutritional Programming

What has been done? – Maternal Nutrition

- As maternal milk is the sole nutrient source interventions are designed to improve milk composition:

Arginine



- No effect on milk arginine (Arg) concentrations[1,2]
- Improved milk yield / intake[1,2]
- Improved suckling piglet performance[1,2]
- *Arg is a functional amino acid*
- Arg concentrations in sows milk are limiting for piglet growth
- Currently no commercial products available
- ***Currently no recommendations for neonatal piglets***

1. ZHU, Cui, et al. Journal of Integrative Agriculture 16.3 (2017): 60345-60347.
2. Mateo, R. D., et al. Journal of animal science 86.4 (2008): 827-835.

Nutritional Programming

What has been done? – Piglet Nutrition

Glutamine

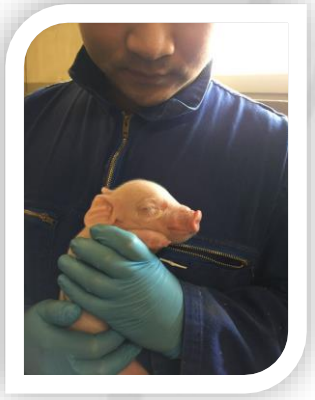
- Improved intestinal development, function
- Studies have all been performed in piglets older than d7 of age

Arginine (N-carbomylglutamate, Citrulline)

- Used in artificial rearing studies
- Improved intestinal development, function
- Low P5C synthase activity (Gln to Arg conversion)

Nutritional Programming

What about our FGR piglets?

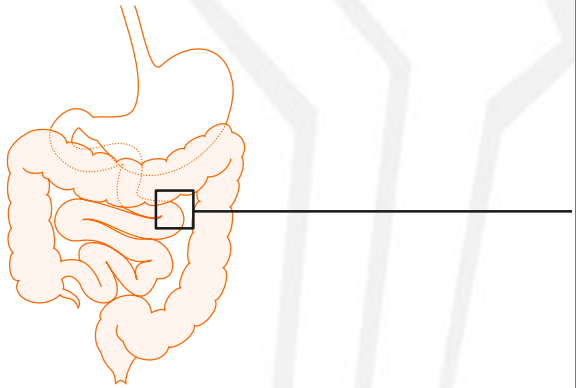


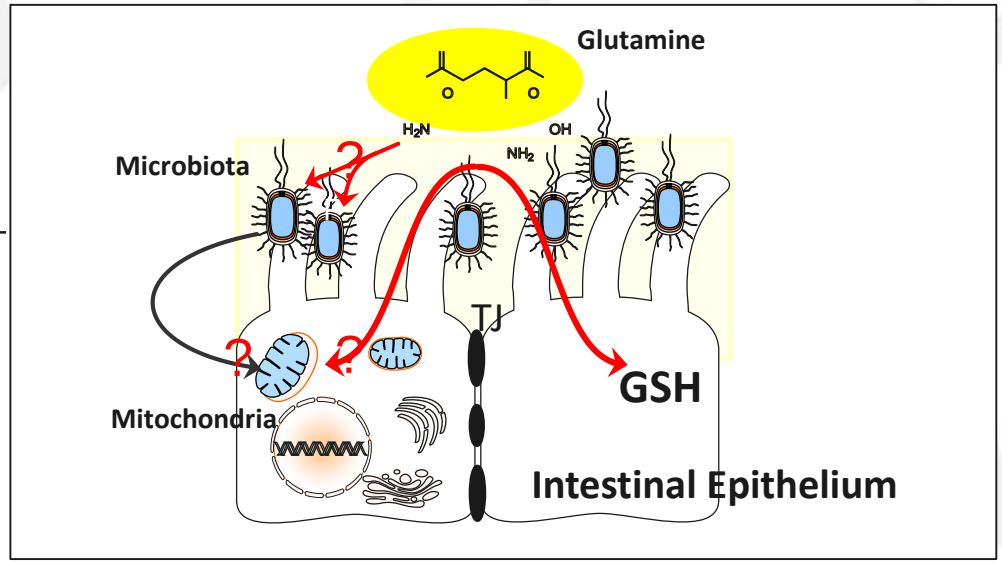
There are currently no know studies that explore the effect on FGR piglets ☹

Project Q-Pig:

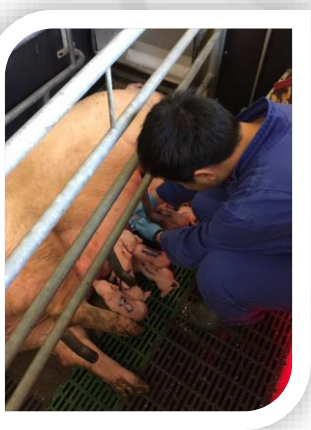
- Focus is the gastrointestinal tract (GIT)
- GIT is the main site of nutrient absorption
- FGR piglets have impaired GIT development

- Gln is the main source of mitochondrial energy
- Gln influences microbiota profiles





Project Q-Pig:



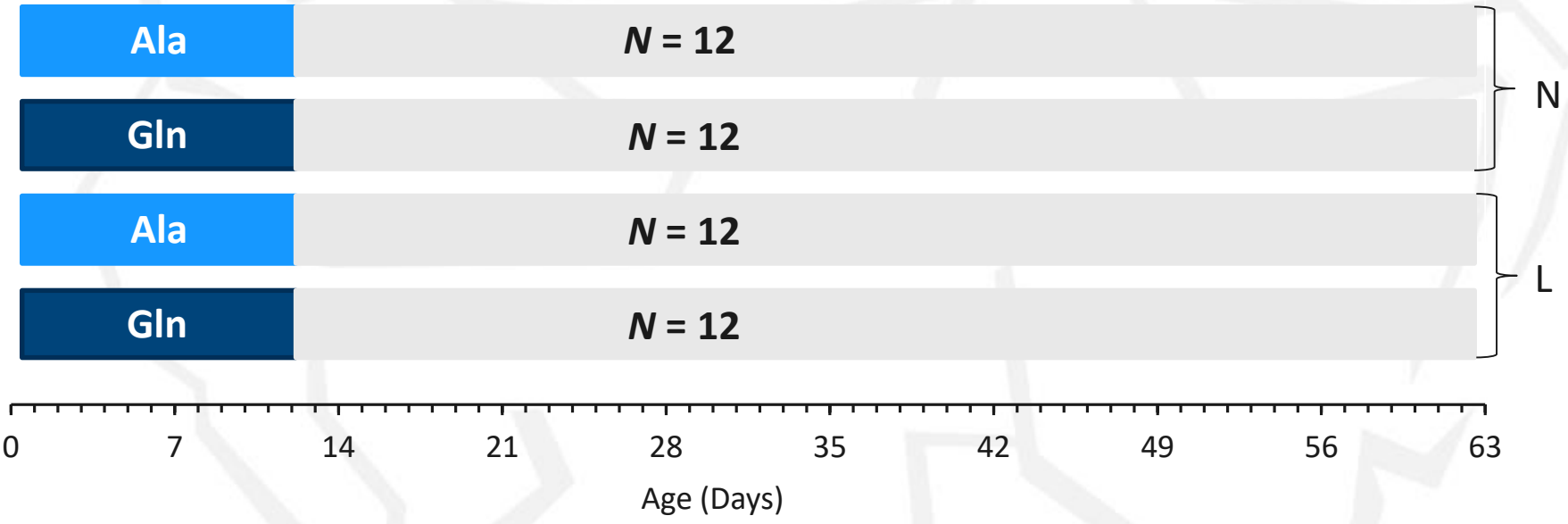
- Gilts
- Litter size $10 \leq \boldsymbol{n} \geq 20$
- Standardized to 12 piglets per sow
- Male piglets only
- 1 LBW (0.8 – 1.2 kg) and 1 NBW (1.4 – 1.8 kg)*
- Minimum 4 piglets per experimental group

Supplementation:

- Glutamine (1g/kg BW); isonitrogenous Alanine (1.219g/kg BW)
- Day after birth until day 11
- 3x / day

***Weight** ranges based on data from the experimental pig facility at the FBN

Project Q-Pig:



Acute

***N* = 48** 5-day

***N* = 48** 12-day

***Total N* = 192 piglets**

Chronic

***N* = 48** 26-day

***N* = 48** 62-day

Experimental Outline

Project Q-Pig:

Samples and Measurements

Piglets

Prior to slaughter all piglets injected with BrDU (cellular proliferation) and 2H5-Phe (fractional synthesis rate)

Blood samples (Birth, 4hrs and slaughter)
(Metabolites)

Mucosa (Duodenum, jejunum, colon ascendance)
(RNA Seq)

Content (Stomach, jejunum, caecum, colon ascendance)
(Microbial profiles, amino acid profiles, microbial metabolites)

Tissue Samples (Liver, spleen, stomach, duodenum, ileum, jejunum, caecum, colon ascendance)
(Fractional synthesis rate, cellular proliferation, amino acid profiles, TCA-metabolites, RNA-Seq, qPCR, biochemical indices, western blotting, IHC, histology)
(jejunum = mitochondrial activity)

Sows

Milk samples (Colostrum, 7d, 14d and 21d)

We patiently await the results

Nutritional Programming

- Nutritional programming encompasses many stages of developmental plasticity
- Pigs are a good model for studying nutritional programming
- Fetal growth restriction provides a good experimental model for testing nutritional interventions
- The neonatal period is a time of developmental plasticity that nutritional programming can be used to improve piglet growth

But to date there is a paucity of studies examining the potential of nutritional programming on the growth of FGR piglets

Q-Pig

- This trial has been designed to address this knowledge gap

LEIBNIZ INSTITUTE
FOR FARM ANIMAL BIOLOGY

How to find us

Leibniz-Institut für Nutztierbiologie FBN

Wilhelm-Stahl-Allee 2
18196 Dummerstorf
Germany

Contact

Dr. Quentin Sciascia

Phone: +49 38208 68 681
Fax: +49 38208 68 652
E-Mail: sciascia@fbn-dummerstorf.de
Internet: www.fbn-dummerstorf.de