



## **PIGWEB**

An infrastructure for experimental research for sustainable pig production

<https://www.pigweb.eu/>



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# **TNA INSTALLATION SHEETS**

Version 05 (31.08.2023)



Research installation:

## ABATTOIR AND CT UNIT

Research organization:

**IRTA**



## ABOUT

The abattoir of IRTA has a lairage room, CO<sub>2</sub> and electrical stunning system, scalding tank, dehairing device, eviscerating area, splitting saw and aerial guide rail. There is a room for viscera and organ evaluation/sampling, cutting room for carcass and meat quality measurements and sampling, and chilling rooms. In addition, the facility has a mobile computed tomography (CT) unit (Phillips Brilliance 16) for live pigs and carcass evaluation. The slaughter capacity is 20 pigs/day with a maximum of two slaughter days per week. The abattoir has a sanitary register.

## UNIT OF ACCESS

**pork.week:** including live animal and carcass weights, slaughtering, carcass lean meat content, fat thickness over *gluteus medius*, pH at 45 min and at 24 h *post mortem*, pH, electrical conductivity, color and drip loss. Samples of subcutaneous fat and one muscle. CT scanning of a complete half carcass (3 mm thickness), determination of six measures (thickness/areas) per carcass in specific anatomical locations, carcass fat/lean and volume associated to each Hounsfield value for further processing.

**Available units: 40**

Typical access: 40 pork.weeks; e.g. 2 treatments x 20 pigs per treatment

## TRIAL START

≥ 3 months after second stage selection

## OUTPUT

Excel file with raw data, carcasses and meat quality information as well as fat and muscles samples that can be further analyzed by the user if needed. Images and Word file with information about the methodology used and descriptive statistics.

## ILLUSTRATIONS

- Font-i-Furnols, M., Luo, X., Brun, A., Lizardo, R., Esteve-Garcia, E., Soler, J., Gispert, M. (2020). Computed tomography evaluation of gilt growth performance and carcass quality under feeding restriction and compensatory growth effects on sensory quality of pork. *Livestock Science*, 237, 104023.
- Zomeño C, Gispert M, Brun A, Carabús A., Font-i-Furnols M. (2016). Predicting the carcass chemical composition and describing its growth in live pigs of different sexes using computed tomographies. *Animal*, 10(1), 172-181.



Monells, SPAIN



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Research installation:

**BEHAVELAB**

Research organization:

**FBN**



Dummerstorf, GERMANY



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## ABOUT

The Behavioural Laboratory (BehaveLab) of FBN provides special equipment and expertise in the assessment of affective emotional states of juvenile pigs. Access is offered to an experimental arena in a video-monitored, sound-attenuated room enabling high-quality audio-visual recordings. These allow for in-depth analyses of behavioural and bioacoustic indicators of psycho-physiological adaptation and coping processes and personality traits based on standardised behavioural tests (e.g., Open Field, Novel Object).

## UNIT OF ACCESS

**pig.week:** including housing, daily caretaking, feeding animals, treatment, blood sampling, lab analyses of blood samples, behaviour tests, general support (in trial design, ethics committee approval and data analysis).

**Available units: 240**

Typical access: 120 pig.weeks, e.g., 40 pigs x 3 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations, support in statistical analysis

## ILLUSTRATION

- Leliveld, L.M.C., Döpjan, S., Tuchscherer, A., Puppe, B. (2017). Vocal correlates of emotional reactivity within and across contexts in domestic pigs (*Sus scrofa*). *Physiology & Behavior* 181, 117-126; Goursoot, C., Döpjan, S., Tuchscherer, A., Puppe, B., Leliveld, L.M.C. (2019). Visual laterality in pigs: monocular viewing influences emotional reactions in pigs. *Animal Behaviour* 154, 183-192.



Research installation:

## **BEHAVIOURAL RESEARCH UNIT**

Research organization:

**WU**



Wageningen, THE NETHERLANDS



<https://www.wur.nl/en/Research-Results/Chair-groups/Animal-Sciences/Department-of-Animal-Sciences/Facilities.htm>



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## **ABOUT**

The behavioural research unit for pigs at the Carus Research barn of Wageningen University (WU), provides many options for experiments with pigs from weaning onwards. It consists of several rooms where tailor-made pens can be built and infrastructure is present for video recording. In addition, two rooms are available for behavioural tests (e.g. cognitive tasks, anxiety tests, social motivation tests, mazes) with microphones and cameras, including a high-resolution thermal camera with a high frame rate.

## **UNIT OF ACCESS**

**pig.week:** including daily caretaking, feeding animals, weighing animals, behavioural observations, general support (in trial design, data analysis, data interpretation).

**Available units: 320**

Typical access: 320 pig weeks; e.g. 8 pens of 4 animals x 10 weeks

## **TRIAL START**

As soon as is possible after second stage selection

## **OUTPUT**

Raw data (e.g. in Excel files) of behavioural observations and tests, and thermal images and video recordings.

## **ILLUSTRATIONS**

- Clouard, C., Le Bourgot, C., Respondek, F., Bolhuis, J.E., & Gerrits, W.J.J. (2018). A milk formula containing maltodextrin, vs. lactose, as main carbohydrate source, improves cognitive performance of piglets in a spatial task. *Scientific Reports*, 8, 9433.
- Reimert, I., Rodenburg, T.B., Ursinus, W.W., Kemp, B., & Bolhuis, J.E. (2014). Responses to novel situations of female and castrated male pigs with divergent social breeding values and different backtest classifications in barren and straw-enriched housing. *Applied Animal Behaviour Science*, 151, 24–35.



Research installation:

## CALORIMETRY

Research organization:

**INRAE**



## ABOUT

The calorimetry facilities of INRAE allow to measure heat production by the pig through indirect calorimetry (i.e. by measuring O<sub>2</sub> consumption and CO<sub>2</sub> production). The simultaneous measurement of physical activity allows to estimate the different components of heat production using statistical analysis techniques. The installation offers access to three calorimeters that range in volume from 1.7 to 12 m<sup>3</sup>, which allow measuring the heat production in individual or in small groups of pigs in controlled ambient conditions (temperature and humidity). After adaptation to diet and housing conditions during 2 weeks, the animals are housed during one week in a calorimeter to measure gas exchanges (one value at every ten second intervals).

## UNIT OF ACCESS

**pig.week:** including feed production, proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, registration of feeding and drinking behaviour and measurement of ambient conditions, physical activity, O<sub>2</sub> consumption and CO<sub>2</sub> production, calculation of heat production and general support (in trial design, ethics committee approval, data analysis, data interpretation).

### Available units: 36

Typical access: 12 pig.weeks; e.g., 2 treatments x 6 individual or 6 small groups of pigs during one week in a calorimeter.

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, N and energy balance, components of total heat (calculations).

## ILLUSTRATION

- K. Quemeneur, L. Montagne, M. Le Gall, Y. Lechevestrier, E. Labussière. 2020. Relation between feeding behaviour and energy metabolism in pigs fed diets enriched in dietary fibre and wheat aleurone. *Animal*, 14 (3), pp.508-519.



Saint-Gilles, FRANCE



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Research installation:

**CREOLE BREED**

Research organization:

**INRAE**



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## ABOUT

The Tropical Animal Experimental Platform (PTEA) of INRAE provides access to Creole breed, a tropical local breed adapted to hot and harsh environmental conditions. Individual production and thermoregulation records can be monitored from the post-weaning phase until slaughter and performances can be compared with Large White breeds. The installation includes an experimental building fitted with automatic feed dispensers and nine single-space electronic feeders for growing pigs with automatic monitoring framework using time-lapse cameras, digestibility rooms, a surgical operating room and a slaughterhouse.

## UNIT OF ACCESS

**pig.week:** including proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, scoring fecal consistency, blood sampling (vein puncture less than 2 min per pig), fecal sampling (snap-frozen within 2 min in liquid nitrogen before storage at -80°C), slaughter, carcass measurements and general support (in trial design, ethics committee approval).

**Available units: 888**

Typical access: 832 pig.weeks; e.g., 2 treatments (two diets, or Creole breed vs conventional crossbred) x 4 pens of 8 animals x 13 weeks

## TRIAL START

≥ 8 months after second stage selection

## OUTPUT

Raw data, calculations, statistical analysis, blood, faeces, urine, saliva and/or feed samples and carcasses.

## ILLUSTRATIONS

- Gourdine, J.L., J. Riquet, R. Rosé, N. Poulet, M. Giorgi, Y. Billon, D. Renaudeau and H. Gilbert (2019). Genotype by environment interactions for performance and thermoregulation responses in growing pigs. *Journal of Animal Science*, 97:3699-3713, doi: 10.1093/jas/skz245.
- Le Sciellour, M., O. Zemb, I. Hochu, J. Riquet, H. Gilbert, M. Giorgi, Y. Billon, J.-L. Gourdine, and D. Renaudeau (2019). Effect of chronic and acute heat challenges on fecal microbiota composition, production and thermoregulation traits in growing pigs. *Journal of Animal Science*, 97:3845-3858, doi: 10.1093/jas/skz222.



Research installation:

## CT LAB

Research organization:

## MEDICOPUS



Kaposvár, HUNGARY



<http://www.medicopus.hu/en>



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## ABOUT

The computed tomography (CT) lab of Medicopus offers the possibility to scan pigs for body composition analysis or getting other quantitative and qualitative traits: (i) body composition analysis on live animals or on carcasses (i.e., volumetric determination of muscle, fat and bone), (ii) surface calculations, (iii) estimation of the bone mineral content, (iv) cardiac CT examinations in live animals at different age, and left and right ventricular analysis, systolic, and diastolic function estimations. **Medicopus' CT imaging lab is located in Kaposvár, Hungary, as is MATE's Perform installation for performance testing. Therefore, it is strongly recommended to combine both installations in a joint project.**

## UNIT OF ACCESS

**pork.week:** including CT scanning procedure (whole body and heart) for 30 pigs as well as housing, preparation and daily care of the animals, anesthesia, necessary consumables, predefined evaluation (body composition, bone density, heart capacity) and general support (in trial design, ethics committee approval, data handling, analysis, storage and interpretation).

**Available units: 180**

Typical access: 90 pork.weeks; e.g. CT examinations at 3 time points (start, halfway and end of the trial) x 3 treatments x 10 animals per treatment.

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw images, image processing results and statistical analysis.

## ILLUSTRATIONS

- Kasza, R., Donkó, T., Matics, Zs., Nagy, I., Csóka, Á., Kovács, Gy., Gerencsér, Zs., Dalle Zotte, A., Cullere, M., Szendrő, Zs.: Rabbit Lines Divergently Selected for Total Body Fat Content: Correlated Responses on Growth Performance and Carcass Traits. *Animals* (2020), 10(10), 1815.
- Romvári R., Szabó A., Andrassy G., Petrás, Z., Donkó T., Horn P. (2008). Cross-sectional imaging assisted selection for heart performance in pigs. *Acta Veterinaria Hungarica* 56:313-322.



Research installation:

**DXA**

Research organization:

**AGROSCOPE**



Posieux, SWITZERLAND



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## ABOUT

The Agroscope Swine Research Unit Posieux offers two calibrated dual-energy X-ray absorptiometry (DXA) apparatuses: one for live grower-finisher pigs and one for carcasses. Regressions to estimate water, ash, protein, fat, and energy content of living pigs and carcasses from DXA values are available. Before and after DXA measurements, pigs are raised in the grower-finisher pig facilities (16 pens with automatic feeders for monitoring individual feed intake). A feed mill, a research abattoir and laboratories for chemical, molecular biology, and microbiology analyses are available as well.

## UNIT OF ACCESS

**pork.week:** including feed formulation and production, proximate analysis of the feed (NIR calibration), daily caretaking, feeding animals, weekly weighing animals, blood sampling, collaboration during DXA measurements, analysis of DXA images, slaughtering and sample collection postmortem at the abattoir and general support (in trial design, ethics committee approval, data analysis and data interpretation).

**Available units: 48**

Typical access: please contact the TNA provider for more information on a typical access for this installation.

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data (e.g., feed composition, body weights, feed intake, and feeding behavior) and processed data (i.e., nutrient composition of pigs or carcasses using the equations to determine water, ash, protein, fat, and energy content from the DXA measurements, developed by Agroscope) compiled in data sheets and ready for statistical analysis.

## ILLUSTRATIONS

- Kasper, C., Schlegel, P., Ruiz-Ascacibar, I., Stoll, P., & Bee, G. (2020). Accuracy of predicting chemical body composition of growing pigs using dual-energy X-ray absorptiometry. *BioRxiv*.
- Bee, G., Kragten, S. A., Früh, B., & Girard, M. (2021). Impact of 100% organic diets on pig performance, carcass composition and carcass nutrient deposition efficiency. *Organic Agriculture*, 1-13.





Research installation:

## EMISSIONS AND ODOURS

Research organization:

**EV ILVO**



## ABOUT

The growing-finishing barn at the Pigs' Campus of EV ILVO is equipped with different ammonia emission reduction systems. It consists of 16 fully separated compartments (also the manure pits). Eight of them consist of fully slatted floors and are connected to the air scrubber. The other eight compartments consist of half-slatted concrete floors and have slanted manure pits. These compartments can be connected to the air scrubber or ventilated via a direct outlet. Each compartment houses up to 48 pigs (8 pens of 6 pigs). The air scrubber system is modularly built, containing several biological air cleaning stages. Advanced emission measuring systems are available to monitor gas concentrations (ammonia, greenhouse gases) and ventilation rates, which result in emission rates.

## UNIT OF ACCESS

**pig.week:** including feed production, daily caretaking, feeding animals, weighing animals, registration of average daily gas emissions (i.e.,  $\text{NH}_3$ ,  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ) through continuous measurements in the barn, measurement of odour concentrations using olfactometry twice in a 5-week period and general support (in trial design, data collection, data analysis and data interpretation).

**Available units: 1440**

Typical access: 480 pig weeks; e.g. 2 compartments x 48 pigs per compartment x 5 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data and calculations

## ILLUSTRATION

- Tabase, R. K., Millet, S., Brusselman, E., Ampe, B., De Cuyper, C., Sonck, B., & Demeyer, P. (2020). Effect of ventilation control settings on ammonia and odour emissions from a pig rearing building. *Biosystems Engineering*, 192, 215-231.



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Research installation:

**ENERGYLAB**

Research organization:

**FBN**



## ABOUT

The respiration chamber EnergyLab is integrated in the Tiertechnikum laboratory of FBN. The open-circuit indirect calorimetry system consists of four respiration chambers for fattening pigs and sows. Chambers are light-cycle and climate-controlled regarding temperature and relative humidity. The airflow through the chambers is controlled, allowing gas exchange measurements of smaller animals. Based on gas exchange measurements ( $O_2$ ,  $CO_2$ ), energy expenditure and nutrient oxidation is quantified. Measurements of  $NH_3$  concentrations to assess nitrogen metabolism and efficiency is possible.

## UNIT OF ACCESS

**pig.week:** including proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, blood sampling, lab analyses of blood samples, general support (in trial design, ethics committee approval and data analysis).

**Available units: 64**

Typical access: 64 pig.weeks; e.g., 2 treatments x 8 pigs per treatment x 4 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations, support in statistical analysis

## ILLUSTRATION

- Krueger R, Derno M, Görs S, Nuernberg G, Metzler-Zebeli BU, Martens K, Nebendahl C, Pfuhl R, Zeyner A, Hammon HM, Metges CC. Higher body fatness in intrauterine growth retarded juvenile pigs is associated with lower fat and higher carbohydrate oxidation during ad libitum and restricted feeding. *Eur J Nutr* 53 (2), 583-597, 2014. DOI: 10.1007/s00394-013-0567-x.



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Research installation:

**EXPPHYSIORO**

Research organization:

**FBN**



Dummerstorf, GERMANY



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## ABOUT

The Experimental Physiology Room (ExpPhysioRo) is integrated in the Tiertechnikum laboratory of FBN. The room is air-conditioned with temperature control and provides places for nutrition and metabolic studies for 12 pigs. The room can host individual pens or metabolic cages for pigs of different bodyweights from 15 up to 100 kg. The facility offers services in pig nutrition and nutrient metabolism research on energy and protein metabolism and feed efficiency, metabolic health, and ontogenetic development, which includes lab analyses.

## UNIT OF ACCESS

**pig.week:** including proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, blood sampling, lab analyses (e.g., plasma tracer enrichment, amino acid profile, plasma metabolites; 64 samples per pig.week) and general support (in trial design, ethics committee approval and data analysis).

**Available units: 40**

Typical access: 32 pig.weeks; e.g., 2 treatments x 8 pigs per treatment x 2 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations, support in statistical analysis

## ILLUSTRATIONS

- Metges CC, Görs S, Martens K, Krüger R, Pfuhl R, Metzler-Zebeli BM, Nebendahl C, Zeyner A, Otten W, Kanitz E, Hammon HM, Nürnberg G. Body composition and plasma lipid and stress hormone levels during 3 weeks of feed restriction and re-feeding in low birth weight female pigs. *J Anim Sci* 93 (3), 999-1014, 2015.
- Rasch I, Görs S, Tuchscherer A, Htoo JK, Kuhla B, Metges CC. Substitution of dietary sulfur amino acids by DL-2-hydroxy-4-methylthiobutyric acid increases remethylation and decreases transsulfuration in weaned piglets. *J Nutr* 149 (3), 432-440, 2019. <https://doi.org/10.1093/jn/nxy296>.



Research installation:

## FEED MILL AND LABORATORY

Research organization:

**IRTA**



Constantí, SPAIN



<http://www.irta.eu/en/centre/irta-mas-bove/>  
<https://www.irta.cat/es/grup/nutricion-animal/>



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## ABOUT

The feed mill of IRTA is used for technological studies, production of experimental feeds, including mash, pelleted and extruded feeds. It is fully automated, with 2 independent manufacture lines, a post-pelleting liquid application, and an extruder. The process of manufacturing is fully traceable to comply with legislation applicable to commercial feed mills: test products, amino acids, mineral and vitamin premixes are added using a bar code system. Technological properties studies (e.g., homogeneity, thermostability, long-term stability) of feed additives can be carried out. Feed samples are analysed to ensure proper mixing in relation to nutrients and homogeneity. The laboratory is equipped with instruments for chemical analysis of ingredients, feeds, and species originated from nutritional assays, and standard protocols are used and complied with quality insurance.

## UNIT OF ACCESS

**ton.feed.week:** including formulation, ingredients, manufacturing, quality control (traceability), bagging, nutrient composition, and pellet quality index. Access to produce 1 ton of feed per week.

**Available units: 18**

Typical access: 1 ton.feed.week

## TRIAL START

≥ 3 months after second stage selection

## OUTPUT

Experimental feeds containing typical ingredients and the test ingredients or additives if relevant. The ingredient and nutrient composition, online feed sampling, temperature records, and pellet quality (Ppost box) will be available.

## ILLUSTRATIONS

- Dersjant-Li Y., Lizardo R. et al., 2020. Functionality of a next generation biosynthetic bacterial 6-phytase in enhancing phosphorus availability to weaned piglets fed a corn-soybean meal-based diet without added inorganic phosphate. *Anim. Nutr.*, 6(1), 24-30.
- Tous N., Esteve-Garcia E., et al., 2016. Addition of arginine and leucine to low or normal protein diets: performance, carcass characteristics and intramuscular fat of finishing pigs. *Spanish J. Agric. Res.* 14 (4): <http://revistas.inia.es/index.php/sjar/article/view/9351>.



Research installation:

**FEED MILL**

Research organization:

**INRAE**



## ABOUT

The experimental feed mill of INRAE has the capacity to manufacture feeds (mash or pelleted) in quantities ranging from a few kilograms to a few tons under well-controlled conditions with different interventions possible during the production process. Specific production conditions can be developed to adapt to particular diet compositions (e.g. high fat content). The associated laboratory ensures the chemical analysis of the feed ingredients used (before manufacturing) and of the experimental diets (after manufacturing). Feeds can be shipped to other PIGWEB installations or to the facility of the TNA users.

## UNIT OF ACCESS

**ton.feed.week:** including support in feed formulation, purchase and chemical analysis of feed ingredients, feed production (1 ton of feed in 1 ton.feed.week) in the chosen form (mash, pellets of defined size; 2.5mm - 3.5mm - 4.5mm), proximate analysis of the feed and feed conditioning for transport (in 25kg bags for production under 300kg, big bag or bulk for production over 300kg).

**Available units: 10**

Typical access: 5 ton.feed.weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Feed produced, production process samples, results of chemical analysis (feed ingredients, complete feed).

## ILLUSTRATION

- E. Labussière, S. Rouhouse, D. Gaudré. 2020. Effet de la granulation des aliments sur l'utilisation de l'énergie chez le porc en croissance : conséquences sur les teneurs en énergie nette des régimes. Journées de la Recherche Porcine 52, 93-98.



Saint-Gilles, FRANCE



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Research installation:

**FEED**

Research organization:

**AU**



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## ABOUT

The experimental small-scale feed factory of AU (built in 2018) can process feed mixtures from 50 up to 2000 kg and offers several processing methods. It includes the following processing equipment: hammer and disc grinding, rolling, mixing in 200-800 liter volumes, pelleting at several diameters with 300 and 1000 kg/h capacity, extrusion, steam heat treatment. Mixing of high fat diets is possible as well. The factory allows combination of the equipment in any order, and the flow of material minimizes the risk of contamination between batches.

## UNIT OF ACCESS

**ton.feed.week:** facility staff are assisting the user by running the processing equipment. In one day, 1 diet with the volume of 50-2000 kg can be prepared. The final diets will be handed over to the user in a big bag. Ingredients are available but not included. For the selected projects, a detailed protocol will be developed in collaboration with a local scientist, and the user is expected at the location for minimum 1 day for this purpose. Technical staff will carry out the practical work.

### Available units: 0.8

Typical access: 0.8 ton.feed.week, where 4 diets can be prepared during 4 days. Alternatively, the 4 days could be spent on processing of feedstuffs or diets, i.e. here the access of 0.8 corresponds to 4 days work in the feed barn.

## TRIAL START

≥ 1 months after second stage selection

## OUTPUT

Feed batches or processed feedstuffs.

## ILLUSTRATIONS

- C.Kobek-Kjeldager, V.A.Moustsen, L.J.Pedersen, P.K.Theil 2021. Impact of litter size, supplementary milk replacer and housing on the body composition of piglets from hyper-prolific sows at weaning. ANIMAL. 15, 100007. DOI <https://doi.org/10.1016/j.animal.2020.100007>
- Hojgaard C.K., T.S. Bruun, P.K. Theil 2020. Impact of milk and nutrient intake of piglets and sow milk composition on piglet growth and body composition at weaning. Journal of Animal Science, 98, skaa060, <https://doi.org/10.1093/jas/skaa060>



Research installation:

**GENSUITE**

Research organization:

**FBN**



## ABOUT

The laboratory for genome and transcriptome analyses (GenSuite) of FBN offers access to holistic 'omics' analyses (i.e., DNA, RNA, microbiota). Studies on individual genome and transcriptome variation help to elucidate the molecular basis of the phenotypic outcome and trait expression. The range of methods includes total RNA-Seq, mRNA-Seq, miRNA-Seq, DNA methylation sequencing (RRBS, WGBS), and amplicon sequencing (16S rRNA). Samples originate from various tissues and specimen, e.g., liver, muscle, blood cells and digesta.

## UNIT OF ACCESS

**lab.week:** including sample preparation, lab analyses and bioinformatics evaluation; 8 samples per week.

### Available units: 4

Typical access: 4 lab.weeks, e.g., 2 treatments x 8 pigs per treatment x 2 tissues

## TRIAL START

≥ 3 months after second stage selection

## OUTPUT

Raw data, calculations, support in statistical analysis

## ILLUSTRATIONS

- Horodyska J, Hamill RM, Reyer H, Trakooljul N, Lawlor PG, McCormack UM, Wimmers K (2019). RNA-seq of liver from pigs divergent in feed efficiency highlights shifts in macronutrient metabolism, hepatic growth and immune response. *Frontiers in Genetics* 10:117.
- Sajjanar B, Trakooljul N, Wimmers K, Ponsuksili S (2019). DNA methylation analysis of porcine mammary epithelial cells reveals differentially methylated loci associated with immune response against *Escherichia coli* challenge. *BMC Genomics* 20(1):1-15.



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Research installation:

**GESTATION**

Research organization:

**EV ILVO**



## ABOUT

The gestation barn at the Pig Research Farm of EV ILVO allows a variety of experiments with gestating sows under controlled conditions. The barn is divided in four compartments (with 20 sows/compartment), each equipped with a feeding station in which four types of feed can be provided.

## UNIT OF ACCESS

**pig.week:** including feed production, daily caretaking, feeding and weighing the animals, faeces collection, faeces and feed analysis (proximate analysis and minerals) and general support (in trial design, data analysis and data interpretation). Supplemental observations or sampling can be performed by the users.

**Available units: 64**

Typical access: 64 pig weeks; e.g. 2 treatments x 8 sows per treatment x 4 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data and calculations.

## ILLUSTRATION

- Van Riet, M., Bos, E. J., Ampe, B., Bikker, P., Vanhauteghem, D., van Bockstaele, F.; Cornillie, P., van den Broeck, W., du Laing, G., Maes, D., Tuyttens, F., Janssens, G., Millet, S. (2018). Long-term impact of zinc supplementation in sows: Impact on claw quality. *Journal of Swine Health and Production*, 26(1), 10-24.



Melle, BELGIUM



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Research installation:

**LACTATION**

Research organization:

**AU**



## ABOUT

The lactation sow unit of AU has 24 traditional farrowing crates and 24 crates for loose-housed sows. Different dietary interventions can be tested for their effect on piglet growth and mortality. The SpotMix feeding system in the individual units can handle numerous feed mixtures and allows feeding multiple diets. Farrowing pens are equipped with a piglet liquid feeding system for e.g. fermented feed.

## UNIT OF ACCESS

**pig.week:** including a standard diet, daily caretaking, feeding, weekly weighing of animals, registration of sow feed intake and piglet mortality. The user is expected to formulate and provide the experimental diet. Feed stuffs and diets can be mixed at AU, well, at the expense of the user or for free in a combined TNA project with AU's Feed installation. For the selected projects, a detailed protocol will be developed, and the user is expected at the farm for minimum 1 day for this purpose. Farm staff will carry out the practical work.

**Available units: 0**

Typical access: 120 pig.weeks; e.g. 24 sows (in traditional pens or loose-housed) x 5 weeks (1 week before farrowing and 4 weeks of lactation). The 24 sows could be divided into 2 or 3 treatment groups.

## TRIAL START

≥ 3 months after second stage selection. If the experimental protocol includes steps not covered by the university's general animal experimental license, an additional 3-4 months may be needed to secure official approval.

## OUTPUT

Raw data. Data handling and reporting can be agreed following specific agreements, at the expense of the user.

## ILLUSTRATIONS

- C.Kobek-Kjeldager, V.A.Moustsen, L.J.Pedersen, P.K.Theil 2021. Impact of litter size, supplementary milk replacer and housing on the body composition of piglets from hyper-prolific sows at weaning. ANIMAL. 15, 100007. <https://doi.org/10.1016/j.animal.2020.100007>
- Hojgaard C.K., T.S. Bruun, P.K. Theil 2020. Impact of milk and nutrient intake of piglets and sow milk composition on piglet growth and body composition at weaning. Journal of Animal Science, 98, skaa060, <https://doi.org/10.1093/jas/skaa060>



Frederiksborg, DENMARK



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Research installation:  
**LIPID-MYCOTOXIN**  
Research organization:  
**MATE**



## ABOUT

The Laboratory of Lipids of MATE offers versatile opportunities in the field of blood and tissue lipids with the primary focus on membrane lipids and fatty acids. Analysis may be performed on animal tissues and feedstuffs as well.

The Laboratory of Mycotoxins of MATE offers widespread opportunities in the field of mycotoxin analysis out of: food, feed, raw materials, animal tissues, etc. Mycotoxins in routine analysis are: FB1-2, T-2, HT-2, DON, ZEA. LCMS-2020 by Shimadzu and a versatile preparation laboratory are available.

## UNIT OF ACCESS

**Lab.week:** including sample preparation, chromatography and general support (in trial design, data analysis and data interpretation). 20 samples are analyzed in one lab.week.

### Available units: 2

Typical access: 2 lab.weeks mycotoxins or 2 lab.weeks lipid analysis or 1 lab.week mycotoxins and 1 lab.week lipid analysis.

## TRIAL START

≥ 2 months after second stage selection

## OUTPUT

Raw data, calculations, statistical analysis and short description of the results and methodology used.

## ILLUSTRATIONS

- Szabó, A., Ali, O., Loki, K. et al (2020) Orally Administered Fumonisin Affect Porcine Red Cell Membrane Sodium Pump Activity and Lipid Profile without Apparent Oxidative Damage. *Toxins*, 12(5), 318.
- Ali, O., Szabó-Fodor, J., Fébel, H., et al. (2019) Porcine Hepatic Response to Fumonisin B1 in a Short Exposure Period: Fatty Acid Profile and Clinical Investigations. *Toxins*, 11(11), 655.



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Research installation:

**LÖVSTA**

Research organization:

**SLU**



## ABOUT

The pig facility Lövsta at SLU is a modern experimental farm for pigs, accommodating 110 sows in an integrated SPF (Specific Pathogen Free) production and fattening about 2500 slaughter pigs a year. The breeding sows are purebred Yorkshires. The farm consists of 7 farrowing/weaner units (12 pens/unit), 7 slaughter units (120 places per unit), a unit for dry sows plus two supplementary units for special research projects.

## UNIT OF ACCESS

**pig.week:** including daily caretaking, ear tagging of piglets, feeding (standard diet) and weighing animals (at birth, at weaning, at 9 weeks and at slaughter), measuring of backfat thickness of sows (at farrowing and weaning), retrieval of individual slaughter records and general support (in trial design and ethics committee approval). Lövsta offers experiments on pigs from birth to slaughter including lactating sows before weaning.

**Available units: 2596**

Typical access: 1200 pig.weeks (slaughter pigs): 3 treatments x 4 pens of 10 animals x 10 weeks or 2200 pig week (from birth to slaughter): 2 treatments x 5 pens of 10 animals x 22 weeks

## TRIAL START

≥ 4-6 months after second stage selection

## OUTPUT

Raw data of production records (e.g. individual growth, feed intake at group level, mortality, medical treatments), slaughter records for individual pigs (e.g. carcass weight, meat percentage), and other as agreed in the contract.

## ILLUSTRATIONS

- Presto Åkerfeldt, M. and Göransson, L. 2019. Effects of using locally produced protein feed ingredients in low protein diets to single-phase-fed growing-finishing pigs. *Acta Agriculturae Scandinavica, Section A — Animal Science*, 68:3, 134-141. <https://doi.org/10.1080/09064702.2019.1657175>
- Åkerfeldt, M., Holmström, S., Wallenbeck, A. Ivarsson, E. 2020. Inclusion of intensively manipulated silage in total mixed ration to growing pigs – influence on silage consumption, nutrient digestibility and pig behaviour, *Acta Agriculturae Scandinavica, Section A — Animal Science*, 68:4, 190-201, DOI: 10.1080/09064702.2020.1725104



Uppsala, SWEDEN



<https://www.slu.se/en/faculties/vh/departments/the-swedish-livestock-research-center/>



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Research installation:

**METABOLISM**

Research organization:

**AGROSCOPE**



Posieux, SWITZERLAND



<https://www.agroscope.admin.ch/agroscope/en/home.html>



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## ABOUT

The Agroscope Swine Research Unit Posieux offers 12 metabolic cages for metabolic balance trials with grower finisher pigs to quantitatively collect urine and feces. Before and after metabolic trials, pigs are raised in the grower-finisher pig facilities (16 pens with automatic feeders for monitoring individual feed intake). A feed mill, a research abattoir and laboratories for chemical, molecular biology and microbiology analyses are available as well.

## UNIT OF ACCESS

**pig.week:** including feed formulation, feed production, proximate analysis of the feed (NIR calibration available), daily caretaking, feeding animals, weekly weighing animals, blood sampling, collaboration during sampling of faeces and urine, collaboration during metabolism experiments, slaughtering and sample collection postmortem at the abattoir and general support (in trial design, ethics committee approval, data analysis and data interpretation).

**Available units: 0**

Typical access: 264 pig.weeks; e.g. 11 weeks (experiment can last from 4 to 13 weeks) x 3 treatments x 8 pigs per treatment.

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data (e.g., feed composition, nutrient content of feces and urine, body weights of the animals, feed intake, and feeding behavior) compiled in data sheets and ready for statistical analysis.

## ILLUSTRATION

- Seoni, E., Rothacher, M., Arrigo, Y., Ampuero Kragten, S., Bee, G., & Dohme-Meier, F. (2021). The Fate of Tannins from Birdsfoot Trefoil and Their Effect on the Nitrogen Balance in Growing Lambs Fed Diets Varying in Protein Level. *Animals* 2021, 11, 190.



Research installation:

**NURSERY**

Research organization:

**EV ILVO**



## ABOUT

The nursery barn at the Pig Research Farm of EV ILVO allows a variety of experiments with newly weaned piglets under controlled conditions. The barn consists of 12 compartments for 48 piglets (8 pens x 6 piglets), with a feeding trough fixed in the front of the pen, covering the total width of the pen, and a double drinking water circuit with 2 drinking nipples per pen.

## UNIT OF ACCESS

**pig.week:** including feed production, proximate analysis of the feed, daily caretaking, feeding and weighing of the animals, scoring faecal consistency and general support (in trial design, data analysis and interpretation). Supplemental observations or sampling can be performed by the users.

**Available units: 2400**

Typical access: 1200 pig weeks; e.g. 48 pens of 5 animals per pen x 5 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data and calculations

## ILLUSTRATIONS

- Millet, S., Minussi, I., Lambert, W., Aluwe, M., Ampe, B., De Sutter, J., & De Campeneere, S. (2020). Standardized ileal digestible lysine and valine-to-lysine requirements for optimal performance of 4 to 9-week-old Piétrain cross piglets. *Livestock Science*, 241, 104263.
- Ulens, T., Demeyer, P., Ampe, B., Van Langenhove, H., & Millet, S. (2015). Effect of grinding intensity and pelleting of the diet on indoor particulate matter concentrations and growth performance of weanling pigs. *Journal of animal science*, 93(2), 627-636.



Melle, BELGIUM



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Research installation:

**NUTRIENT BALANCE**

Research organization:

**EV ILVO**



## ABOUT

The nutrient balance unit of EV ILVO offers the equipment and expertise for carrying out digestibility trials. A large grinder and autoclave are present to accurately determine body composition of pigs.

## UNIT OF ACCESS

**pig.week:** including feed production, proximate analysis of the feed, daily caretaking, feeding and weighing the animals, faeces collection, faeces analysis, grinding the selected animal carcasses, carcass analysis, and general support (in trial design, data analysis and data interpretation).

**Available units: 768**

Typical access: 768 units of access; e.g. 2 treatments  
8 pens of 3 animals per treatment x 16 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data and calculations

## ILLUSTRATION

- Van den Broeke, A., Leen, F., Aluwé, M., Van Meensel, J., & Millet, S. (2017). Effect of slaughter weight and sex on carcass composition and N-and P-efficiency of pigs. In 68th Annual Meeting of the European Federation for Animal Science.



Melle, BELGIUM



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Research installation:

**PERFORM**

Research organization:

**MATE**



## ABOUT

The Research Unit for Animal Nutrition of MATE has the facility to conduct performance trials, digestibility or metabolic studies. Performance studies with 30 individual pens for growing-finishing pigs (25-120 kg) are available. In addition, metabolic studies with 30 individual metabolic cages for piglets (7-25 kg) and 24 for growing-finishing pigs (25-80 kg) are offered. A surgery room serves the preparation for cannula implantation if needed. **MATE's Perform installation for performance testing is located in Kaposvár, Hungary, as is Medicopus' CT lab for CT imaging. Therefore, it is strongly recommended to combine both installations in a joint project.**

## UNIT OF ACCESS

**pig.week:** including feed production, proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, measuring feed intake, scoring fecal consistency, blood sampling, fecal, urine and/or digesta sampling, surgery to implant cannula and general support (in trial design, ethics committee approval, data analysis and data interpretation).

**Available units: 627**

Typical access: 300 pig.weeks; individually kept 30 growing-finishing pigs for 10 weeks (2-5 treatments), or 210 pig.weeks; digestibility study 30 ileum cannulated piglets (2-4 treatments) for 5 weeks including the preparation with surgery (2 weeks recovery/piglet).

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations, statistical analysis and short description of the results.

## ILLUSTRATIONS

- Nagy, K., Fébel, H., Halas, V., Tóth, T. (2021) The effect of inclusion of fibre-rich by-products on the performance of growing and finishing pigs (pilot study). *Acta Agriculturae Scandinavica Section A-Animal Science*, 70 (1): 23-30.
- Zeebone, Y.Y, Kovacs, M., Bóta, B., Halas, V. (2020) Effects of dietary fumonisins on nutrient digestibility in weanling pigs. *Acta Fytotechnica in Animal Production 23: 2020 Future Perspectives in Animal Production*, 23-28.



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Research installation:

**PIGHOUSE**

Research organization:

**FBN**



## ABOUT

The experimental pig farm PigHouse of FBN offers space for 80 and 24 sows (German Landrace; Angler Saddleback) plus their offspring, with conventional or organic housing. In addition, 60 places for fattening pigs are available, also with conventional or organic housing. Weighing troughs for fattening pigs, an automatic feeding system for sows to measure individual feed intake, an air-conditioning system, outdoor space, silos for seven different types of feed and a central mixing and distribution unit are all present at the facility.

## UNIT OF ACCESS

**pig.week:** including proximate analysis of the feed, daily caretaking, feeding animals, weighing animals, blood sampling, lab analyses, general support (in trial design, ethics committee approval and data analysis).

**Available units: 420**

Typical access: 420 pig.weeks; e.g. 2 treatments x 10 sows per treatment x 5 weeks + 8 piglets/litter x 20 sows x 2 weeks

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations, support in statistical analysis

## ILLUSTRATIONS

- Rehfeldt, Lang IS, Görs S, Hennig U, Kalbe C, Stabenow B, Brüßow K-P, Pfuhl R, Bellmann O, Nürnberg G, Otten W, Metges CC. Limited and excess dietary protein during gestation affects growth and compositional traits in gilts and impairs offspring fetal growth. *J Anim Sci.* 89 (2), 329-341, 2011. DOI:10.2527/jas.2010-2970.
- Nebendahl C, Krüger R, Görs S, Albrecht E, Martens K, Hennig S, Storm N, Höppner W, Pfuhl R, Metzler-Zebeli BU, Hammon HM, Metges CC. Effects on transcriptional regulation and lipid droplet characteristics in the liver of female juvenile pigs after early postnatal feed restriction and refeeding are dependent on birth weight. *PLoS ONE* 8 (11): e76705, 2013. doi:10.1371/journal.pone.0076705.



Dummerstorf, GERMANY



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Research installation:

**PIGLETS**

Research organization:

**AU**



## ABOUT

The piglets installation at the Foulum Campus of AU offers the possibility to perform various trials with individually housed piglets. Ten identical rooms with 16 pens each are available for individual housing. If appropriate, each pen can house 4 piglets or the pens can be connected in pairs. All rooms are temperature and humidity regulated, allowing housing of piglets from weaning to 30 kg.

## UNIT OF ACCESS

**pig.week:** including daily caretaking, feeding animals, weighing animals (initial and final bodyweight) and measuring feed intake. The user is expected to formulate and provide the experimental diets. Feedstuffs and diets can be mixed at AU as well, at the expense of the user or for free in a combined TNA project with AU's Feed installation. For the selected projects, a detailed protocol will be developed, and the user is expected at the location for minimum 1 day for this purpose. Barn staff will carry out the practical work.

**Available units: 288**

Typical access: 288 pig.weeks; e.g. 96 crossbred piglets (6-7 kg) distributed to 4 treatments with 24 piglets/treatment x 3 weeks

## TRIAL START

≥ 3 months after second stage selection. If the experimental protocol includes steps not covered by the university's general animal experimental license, an additional 3-4 months may be needed to secure official approval.

## OUTPUT

Raw data. Data handling and reporting can be agreed following specific agreements, at the expense of the TNA user.

## ILLUSTRATIONS

- Sørensen, P., J.V. Nørgaard. 2016. Starfish (*Asterias rubens*) as feed ingredient for piglets. *Animal Feed Science and Technology*. 211, 181-188. DOI: <https://doi.org/10.1016/j.anifeedsci.2015.11.012>
- J. V. Nørgaard, N. Canibe, E. A. Soumeh, B. B. Jensen, B. Nielsen, P. Derkx, M. D. Cantor, K. Blaabjerg, and H. D. Poulsen. 2016. Evaluation of in situ valine production by *Bacillus subtilis* in young pigs. *ANIMAL*. 10, 1796 – 1802 DOI: <https://doi.org/10.1017/S1751731116000781>



Tjele, DENMARK



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Research installation:

**PLF**

Research organization:

**INRAE**



## ABOUT

The Precision Livestock Farming (PLF) facility of INRAE is unique in that it can be used to offer feed “à la carte” to growing pigs. The facility houses 90 pigs in a single unit. Different monitoring systems allow measuring the individual body weight (using a sorting system), feed intake (and feed intake patterns, using 8 precision feeders), and water consumption (with 8 connected water dispensers). This information is used in real-time to provide a combination of up to four diets to each pig.

## UNIT OF ACCESS

**pig.week:** including feed production, proximate analysis of the feed, provision of pigs at post weaning stage, daily caretaking, feeding animals, weighing animals, water intake measurement, shipping to a commercial slaughter facility and general support (in trial design, ethics committee approval, data analysis and data interpretation).

**Available units: 1170**

Typical access: 1170 pig.weeks; e.g. 90 pigs x 13 weeks (with pigs each of which can receive a different diet or a combination of diets).

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data, calculations

## ILLUSTRATION

- A.M Serviento, L. Brossard, D. Renaudeau (2018). An acute challenge with a deoxynivalenol-contaminated diet has short- and long-term effects on performance and feeding behavior in finishing pigs. *Journal of animal science*, 96, 5209-5221.



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Research installation:

**RAPID ANALYSIS**

Research organization:

**MATE**



## ABOUT

The Laboratory of Rapid Analytical Methods of MATE offers collaboration in the application of measurement technologies to evaluate quality parameters of feed and animal products and data processing methods. The equipment may be used in metabolic studies as well. Near infrared spectroscopy (benchtop spectrometers: FOSS NIRSystems 6500, FOSS DS2500) and artificial aroma sensing using electronic nose (AlphaMOS FOX 4000) and electronic tongue (AlphaMOS Astree) technologies are available.

## UNIT OF ACCESS

**lab.week:** including sample preparation, scanning and general support (in trial design, data analysis and data interpretation). Electronic nose analyses 500 samples in 4 lab.weeks; electronic tongue measures 250 samples in 4 lab.weeks; NIR instrument measures 1000 samples in 8 lab.weeks.

### Available units: 8

Typical access: 4 lab.weeks electronic tongue, 4 lab.weeks electronic nose or 8 lab.weeks NIR

## TRIAL START

≥ 2 months after second stage selection

## OUTPUT

Raw data, calculations, statistical analysis and short description of the results and methodology used.

## ILLUSTRATIONS

- Bazar, G., Eles, V., Kovacs, Z., Romvari, R., Szabo, A. (2016); Multicomponent blood lipid analysis by means of near infrared spectroscopy, in geese. *Talanta* 155: 202-211.
- Bazar, G., Kovacs, Z., Tsenkova, R. (2016); Evaluating spectral signals to identify spectral error. *PLoS ONE* 11(1): e0146249. doi: 10.1371/journal.pone.0146249



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Research installation:

## RESPIROMETRY UNIT

Research organization:

**WU**



Wageningen, THE NETHERLANDS



<https://www.wur.nl/en/research-results/chair-groups/animal-sciences/animal-sciences/facilities.htm>



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## ABOUT

The experimental climatized respirometry unit at Carus Research Facilities of Wageningen University (WU) allows to measure heat production through indirect calorimetry. Eight size-adjustable units with a maximum of 4.5 x 2.7 x 2.5m each are available, to be used for individually or group-housed pigs. All rooms are climate-controlled, with HEPA filtered air flows if needed. In addition to energy and N balances (based on CO<sub>2</sub> production and O<sub>2</sub> consumption), these facilities are well equipped for measurement of <sup>13</sup>CO<sub>2</sub>, H<sub>2</sub>, CH<sub>4</sub>, NH<sub>3</sub> and other emissions.

## UNIT OF ACCESS

**pig.week:** including supply of the animals, housing, preparation, feeding and daily care, consumables, recovery tests, calibration of gas analysers, sensors and flow meters and participation of technicians for daily checks, clinical examination, sampling, support in chemical analysis of parameters required for a complete N and energy balance and apparent faecal digestion, screening of raw data. It also includes cleaning and disinfection of the experimental rooms as well as disposal of carcasses and general support (in trial design, data analysis, data interpretation).

### Available units: 24

Typical access: please contact the TNA provider for more information on a typical access for this installation.

## TRIAL START

≥ 4-8 months after second stage selection

## OUTPUT

Raw data on gas exchange, heat production, pig weight, feed intakes, activity measurements, and excreta collections.

## ILLUSTRATIONS

- van der Meer Y, Jansman AJM and Gerrits WJJ (2020) Low sanitary conditions increase energy expenditure for maintenance and decrease incremental protein efficiency in growing pigs. *Animal* 14:9: 1811-1820.
- Clouard C, Lannuzel C, Le Bourgot C and Gerrits WJJ (2020) Lactose and Digestible Maltodextrin in Milk Replacers Differently Affect Energy Metabolism and Substrate Oxidation: A Calorimetric Study in Piglets. *Journal of Nutrition* 00:1-9



Research installation:

**RFI LINES**

Research organization:

**INRAE**



le Magneraud Surgères, FRANCE



[www6.nouvelle-aquitaine-poitiers.inrae.fr/genesi/](http://www6.nouvelle-aquitaine-poitiers.inrae.fr/genesi/)  
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## ABOUT

The RFI lines of INRAE originate from a long-term program in which pig lines have been selected divergently for 10 generations for Residual Feed Intake (RFI), an indicator of feed efficiency. Individual production records are monitored from the post-weaning phase until slaughter. In addition, access can be provided to modern pig breeds and Chinese Meishan pigs, and crossbreds between these lines and breeds. The lines and breeds can be housed in a conventional facility or in a newly-build facility for organic farming. Due to planned programs, the latter facility will be available for TNA activities from 2024.

## UNIT OF ACCESS

**pig.week:** including provision of the pigs at the post-weaning stage, raising and management of the animals, daily caretaking, feed production, feeding animals, weighing animals, faeces or blood sampling, health monitoring, shipping to a commercial slaughter facility and general support (in trial design, ethics committee approval).

**Available units: 3200**

Typical access: 3200 pig.weeks; e.g. 20 weeks (from post-weaning to slaughter) x 2 RFI lines (or breeds or crossbreds) x 80 pigs per line.

## TRIAL START

≥ 6 months after second stage selection

## OUTPUT

Raw data

## ILLUSTRATIONS

- Gilbert H., Billon Y., Brossard L., Faure J., Gatellier P., Gondret F., Labussière E., Lebreton B., Lefaucheur L., Le Floc'h-Burban N., Louveau I., Merlot E., Salaun M.-C., Montagne L., Mormède P., Renaudeau D., Riquet J., Gaillard C., Van Milgen J., Vincent A., Noblet J. (2017). Review. Divergent selection for residual feed intake in the growing pig. *animal*, 11(9):1427-1439. DOI: <https://doi.org/10.1017/S175173111600286X>. Réf. HAL: hal-01547532
- A Aliakbari, O Zemb, Y Billon, C Barilly, I Ahn, H Gilbert. Genetic relationships between feed efficiency and gut microbiome in pig lines selected for residual feed intake, *Journal of Animal Breeding and Genetics*. <https://doi.org/10.1111/jbg.12539>