

Universitat
de Lleida



Effects of Heat Stress on energy and protein metabolism in Iberian and crossbred pigs

L. Sarri¹, E. Labussière², J. Balcells¹ and G. de la Fuente¹

¹ Universitat de Lleida – Agrotecnio - CERCA, Spain

² INRAE UE 3P, France

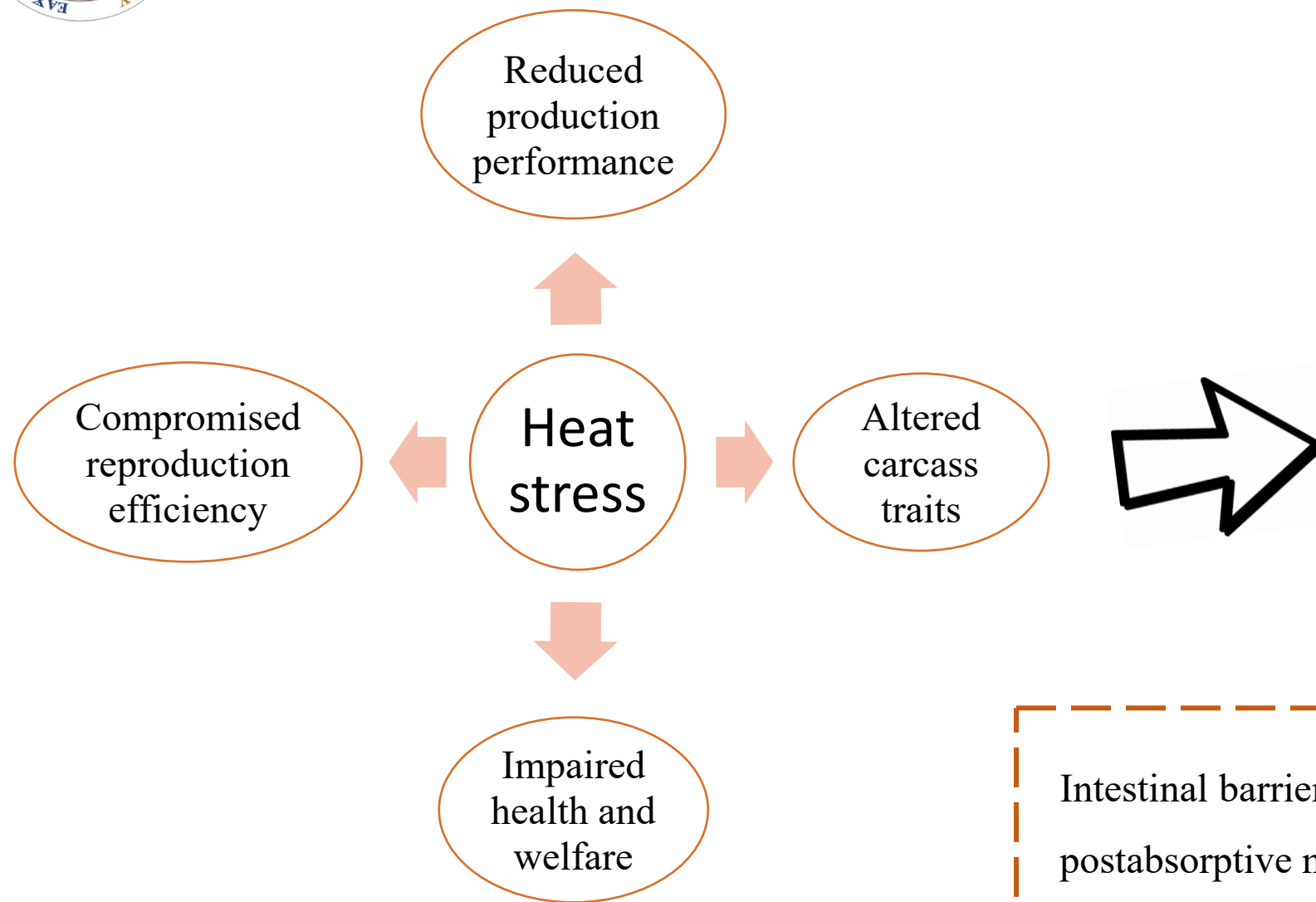


Horizon 2020
European Union Funding
for Research & Innovation





Consequences of heat stress:



Explained by indirect effects:

➤ **Reduction of feed intake**

But also by direct effects:

➤ **Altered physiological functions**

➤ **Metabolic adjustments**

Intestinal barrier disruption, inflammatory state, altered postabsorptive metabolism, and endocrine responses

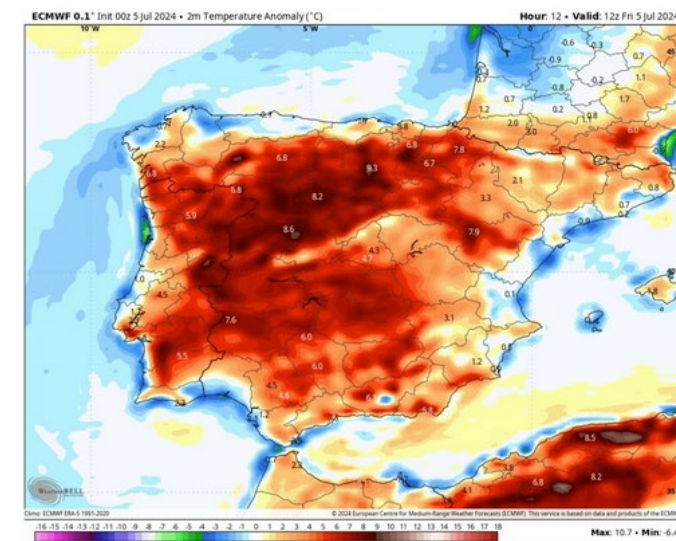
Pig breeds with higher genetic potential for high production yield

have less tolerance to HS due to:

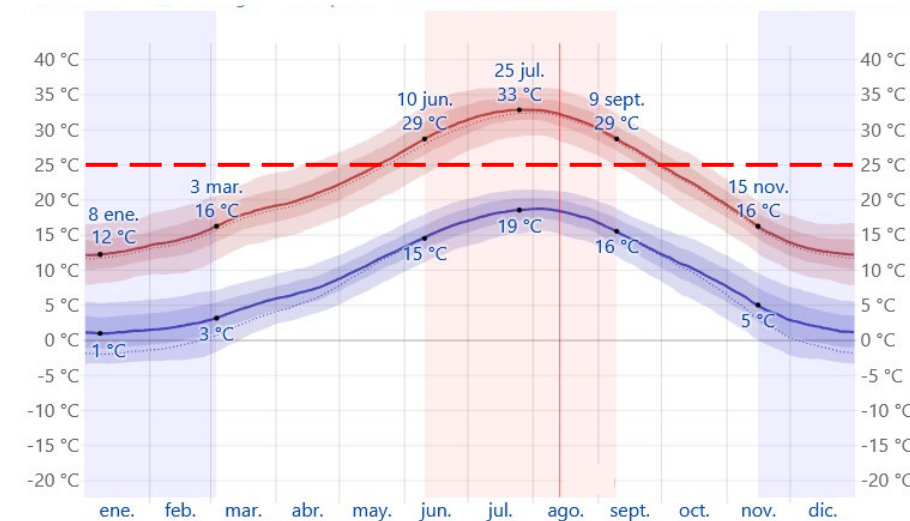
- Accelerated body metabolism
- Elevated internal heat production
- Poor thermoregulation

(Renaudeau et al., 2011)

The main pig producing areas in Spain are under hot summer Mediterranean climate



Average maximum and minimum temperature in Lleida (2017-2024)



Iberian pigs

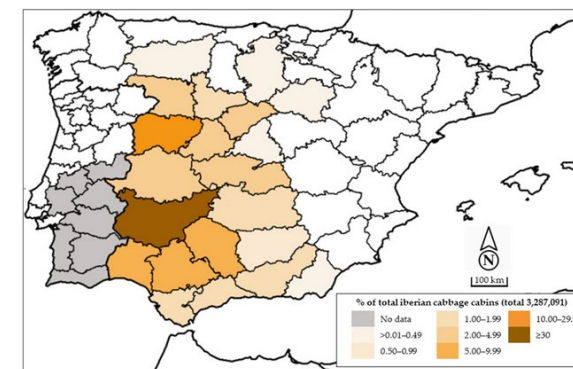
An autochthonous non-selected pig breed of the Mediterranean used for high quality dry-cured meat products.

Characterized by:

- Great appetite
- Fatness (high basal lipogenesis; IMF)
- Low lean tissue deposition (Nieto et al. 2012)

It is considered to be highly adapted to its natural ecosystem (Lopez-Bote, 1998)

However, it is argued that their thick subcutaneous fat layer could make Iberian pigs more sensitive to HS (Pardo et al., 2022).





Objectives

Study the possible differences in heat stress effects in Iberian pigs and conventional crossbred pigs, analyzing:

- Feeding and drinking behavior
- Production performance and body temperature
- Nitrogen and energy balance



Material and methods

Crossbred pigs [60.9 ± 1.91 kg BW]

Pietrain $\times$ (Landrace $\times$ Large White)



Thermoneutral temperature

(23.5 °C; 60 % RH) **TN**

Heat stress temperature

(33.5 °C; 60 % RH) **HS**

Total of **22**
entire male pigs

Iberian pigs [64.1 ± 1.85 kg BW]



Thermoneutral temperature

(23.5 °C; 60 % RH) **TN**

Heat stress temperature

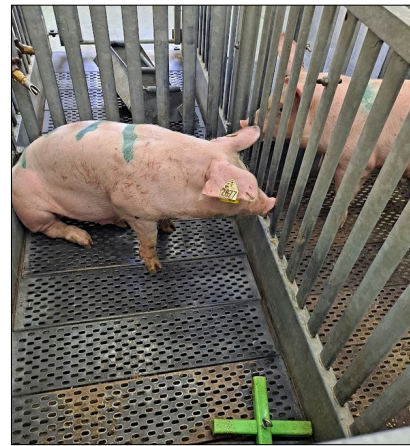
(33.5 °C; 60 % RH) **HS**

2 $\times$ 2 factorial arrangement

Adaptation (21 days) and experimental (6) period:

- Environmental conditions [TN: 23.5 °C; HS: 33.5 °C]

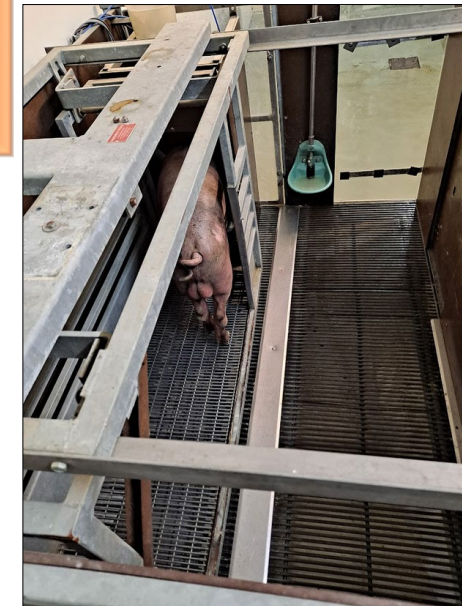
1st week adaptation



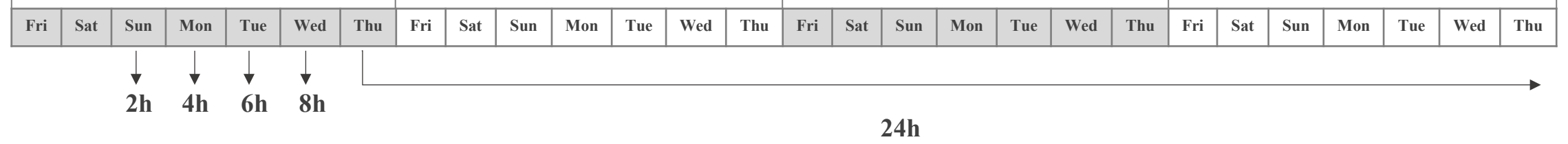
2nd week adaptation



3rd week adaptation



Experimental week



Experimental period (last 6 days):

- Housed individually in respiration chambers
- Environmental conditions [TN: 23.5 °C; HS: 33.5 °C]
- *Ad libitum* feed and water

Measurements:

- Initial and final BW
- Feeding and drinking behavior
- Feces and urine excretion
- Rectal temperature
- O₂ consumption + CO₂ and CH₄ production
- Physical activity



Data analyzed by PROC MIXED procedure
Breed (B), treatment (T) and their
interaction ($T \times B$) as fixed effects.

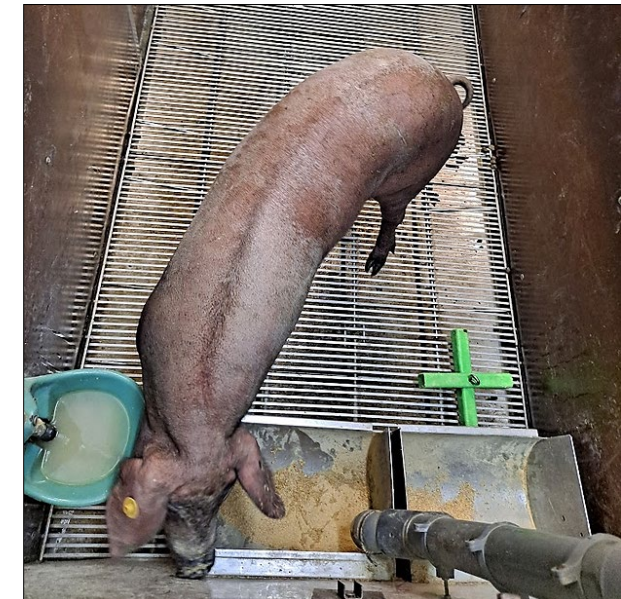
Pig considered as experimental unit.



Feeding behavior

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N° trough visits	8.61	11.09	12.05	11.35	1.753	0.309	0.621	0.381
Feed intake (kg/day)	2.25	1.18 ↓	2.41	1.11 ↓	0.225	0.825	< 0.0001	0.619
Duration of intake (min)	87	49 ↓	106	44 ↓	11.1	0.538	0.001	0.292
Feces excretion (kg DM/day)	2.00	0.95 ↓	1.81	1.04 ↓	0.220	0.824	0.001	0.532

≈ 50%
↓



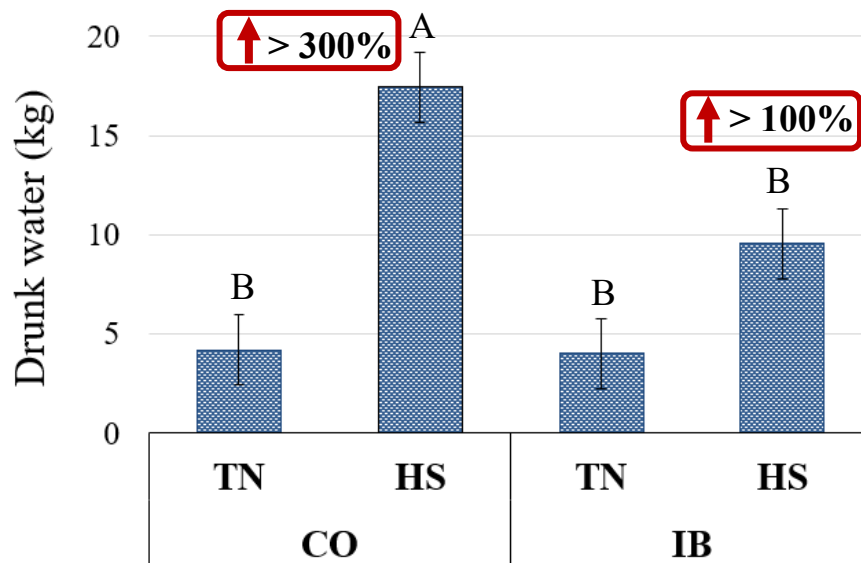
Drinking behavior

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N° drinker visits	13.76	61.00 ↑	18.60	49.44 ↑	5.260	0.534	< 0.0001	0.141 > 100%
Duration of drinking (min/day)	11.96	59.45 ↑	11.29	43.59 ↑	4.576	0.092	< 0.0001	0.119 > 200%
Drunk water (kg/day)	4.18 ^B	17.44 ^A	4.02 ^B	9.54 ^B	1.760	0.038	< 0.0001	0.045
Urine excretion (kg/week)	12.67 ^B	75.86 ^A	13.28 ^B	37.00 ^{AB}	9.151	0.055	0.000	0.048



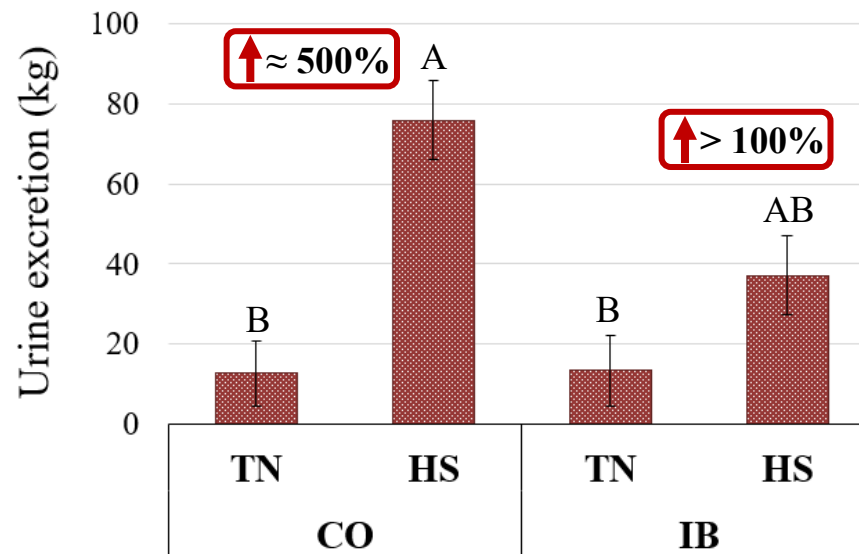
Drinking behavior

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N° drinker visits	13.76	61.00 ↑	18.60	49.44 ↑	5.260	0.534	< 0.0001	0.141 > 100%
Duration of drinking (min/day)	11.96	59.45 ↑	11.29	43.59 ↑	4.576	0.092	< 0.0001	0.119 > 200%
Drunk water (kg/day)	4.18 ^B	17.44 ^A	4.02 ^B	9.54 ^B	1.760	0.038	< 0.0001	0.045
Urine excretion (kg/week)	12.67 ^B	75.86 ^A	13.28 ^B	37.00 ^{AB}	9.151	0.055	0.000	0.048



Drinking behavior

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N° drinker visits	13.76	61.00 ↑	18.60	49.44 ↑	5.260	0.534	< 0.0001	0.141 > 100%
Duration of drinking (min/day)	11.96	59.45 ↑	11.29	43.59 ↑	4.576	0.092	< 0.0001	0.119 > 200%
Drunk water (kg/day)	4.18 ^B	17.44 ^A	4.02 ^B	9.54 ^B	1.760	0.038	< 0.0001	0.045
Urine excretion (kg/week)	12.67 ^B	75.86 ^A	13.28 ^B	37.00 ^{AB}	9.151	0.055	0.000	0.048





Pig performance and rectal temperature

	CROSSBRED		IBERIAN		SEM	<i>P</i> -value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
Mean BW (kg)	63.26	57.41	66.43	63.72	2.906	0.125	0.163	0.597
ADG (g/day)	0.99	-0.06↓	0.46	-0.24↓	0.205	0.103	0.001	0.401
Rectal temperature (°C)	39.17	39.64↑	39.22	40.11↑	0.165	0.131	0.001	0.222

Heat stress leads to:

- Reduced average daily gain
- Hyperthermia



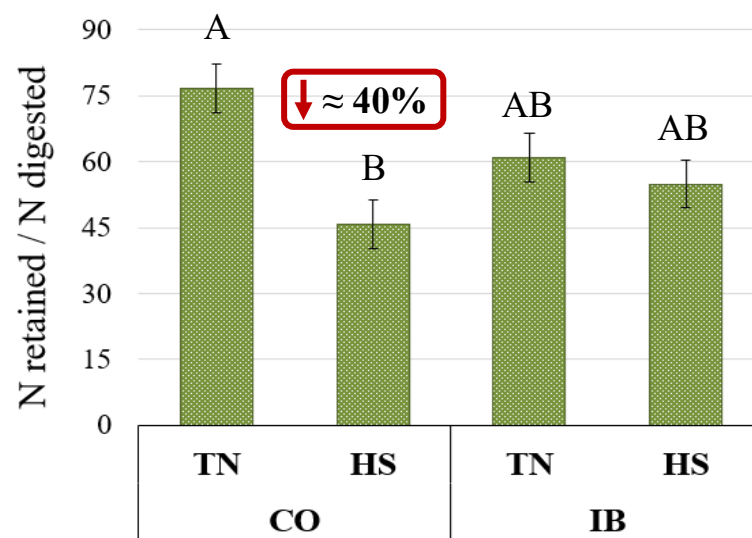
Nitrogen balance

(g N/day)	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N intake	66.23	35.55↓	66.64	39.88↓	7.266	0.748	0.001	0.792
N Feces	15.67	6.80↓	14.70	7.76↓	1.909	0.997	< 0.001	0.624
N urine	11.72	14.46	20.06	14.87	2.839	0.146	0.673	0.184
N Digestible	50.56	28.75↓	51.94	32.12↓	5.615	0.679	0.002	0.863
N retained	38.83	14.28↓	31.88	17.25↓	4.791	0.684	0.001	0.318
N retained/N digested (%)	76.73 ^A	45.79 ^B	61.01 ^{AB}	54.89 ^{AB}	5.479	0.556	0.004	0.039



Nitrogen balance

(g N/day)	CROSSBRED		IBERIAN		SEM	<i>P</i> -value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
N intake	66.23	35.55 ↓	66.64	39.88 ↓	7.266	0.748	0.001	0.792
N Feces	15.67	6.80 ↓	14.70	7.76 ↓	1.909	0.997	< 0.001	0.624
N urine	11.72	14.46	20.06	14.87	2.839	0.146	0.673	0.184
N Digestible	50.56	28.75 ↓	51.94	32.12 ↓	5.615	0.679	0.002	0.863
N retained	38.83	14.28 ↓	31.88	17.25 ↓	4.791	0.684	0.001	0.318
N retained/N digested (%)	76.73 ^A	45.79 ^B	61.01 ^{AB}	54.89 ^{AB}	5.479	0.556	0.004	0.039





Energy balance

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
Heat production; HP (kJ/kg BW ^{0.60} per day)	1402	1111 ↓	1447	1054 ↓	72.0	0.930	< 0.001	0.488
¹ RHP/HP (%)	69.82	63.22 ↓	69.35	59.89 ↓	1.730	0.287	< 0.001	0.421
² AHP/HP (%)	16.39	24.47 ↑	14.94	25.92 ↑	1.112	0.999	< 0.0001	0.208
³ TEFst/HP (%)	13.79	12.31	15.72	14.19	1.394	0.190	0.295	0.986
Energy retained (kJ/kg BW ^{0.60} per day)								
as protein	395	157	314	187	36.5	0.489	<0.0001	0.144
as lipid	558	206	703	341	131.8	0.301	0.014	0.969
Respiratory quotient (RQ)	1.14	1.03	1.21	1.09	0.022	0.008	< 0.0001	0.722

¹ RHP: Resting heat production

² AHP: Heat production related with physical activity

³ TEFst: short-term thermic effect of feeding

Energy balance

	CROSSBRED		IBERIAN		SEM	P-value		
	TN	HS	TN	HS		Breed	Treatment	Breed × treatment
Heat production; HP (kJ/kg BW ^{0.60} per day)	1402	1111 ↓	1447	1054 ↓	72.0	0.930	< 0.001	0.488
¹ RHP/HP (%)	69.82	63.22 ↓	69.35	59.89 ↓	1.730	0.287	< 0.001	0.421
² AHP/HP (%)	16.39	24.47 ↑	14.94	25.92 ↑	1.112	0.999	< 0.0001	0.208
³ TEFst/HP (%)	13.79	12.31	15.72	14.19	1.394	0.190	0.295	0.986
Energy retained (kJ/kg BW ^{0.60} per day)								
as protein	395	157 ↓	314	187 ↓	36.5	0.489	<0.0001	0.144
as lipid	558	206 ↓	703	341 ↓	131.8	0.301	0.014	0.969
Respiratory quotient (RQ)	1.14	1.03 ↓	1.21	1.09 ↓	0.022	0.008	< 0.0001	0.722

¹ RHP: Resting heat production

² AHP: Heat production related with physical activity

³ TEFst: short-term thermic effect of feeding



Heat stressed pigs:

- Decreased feed intake
- Increased water consumption and urine excretion, **especially in crossbred pigs**
- Showed hyperthermia
- Worsened their growth performance
- Decreased heat production (HP):
 - Reducing the contribution to the resting HP
 - Increasing the contribution for the physical activity
- Reduced energy retention in form of protein
- Reduced respiratory quotient, **although it was higher in Iberian pigs**



Take home message:

- The greatest differences in production performance, N and energy balance were found between environmental treatments, rather than between breeds under Heat Stress.
- Iberian pigs have a more stable water balance under Heat Stress conditions compared to the most selected breed



- Nieto, R., Lara, L., Barea, R., García-Valverde, R., Aguinaga, M.A., Conde-Aguilera, J.A., Aguilera, J.F., 2012. Response analysis of the Iberian pig growing from birth to 150 kg body weight to changes in protein and energy supply. *J. Anim. Sci.* 90, 3809–3820.
- Pardo, Z., Seiquer, I., Lachica, M., Nieto, R., Lara, L., Fernández-Fígares, I. Exposure of growing Iberian pigs to heat stress and effects of dietary betaine and zinc on heat tolerance. *Journal of Thermal Biology.* 2022, 106, 1036230
- Rojas-Downing, M. Melissa, Nejadhashemi, A. Pouyan, Harrigan, Timothy Woznicki, Sean A. Climate change and livestock: impacts, adaptation, and mitigation. 2017 (16) 145-163
- Ross, J.W.; Hale, B.J.; Gabler, N.K.; Rhoads, R.P.; Keating, A.F.; Baumgard, L.H. Physiological consequences of heat stress in pigs. *Anim. Prod. Sci.* 2015, 55, 1381–1390



**Thank you for your
attention!**



laura.sarri@udl.cat

