iSAGE Training Course and Workshop

INNOVATIONS TO IMPROVE SUSTAINABILITY IN THE SHEEP AND GOAT SECTOR (Zaragoza, Spain, from 10 to 13 December 2019)

Genetic approaches to improve sustainability and adapting to climate change

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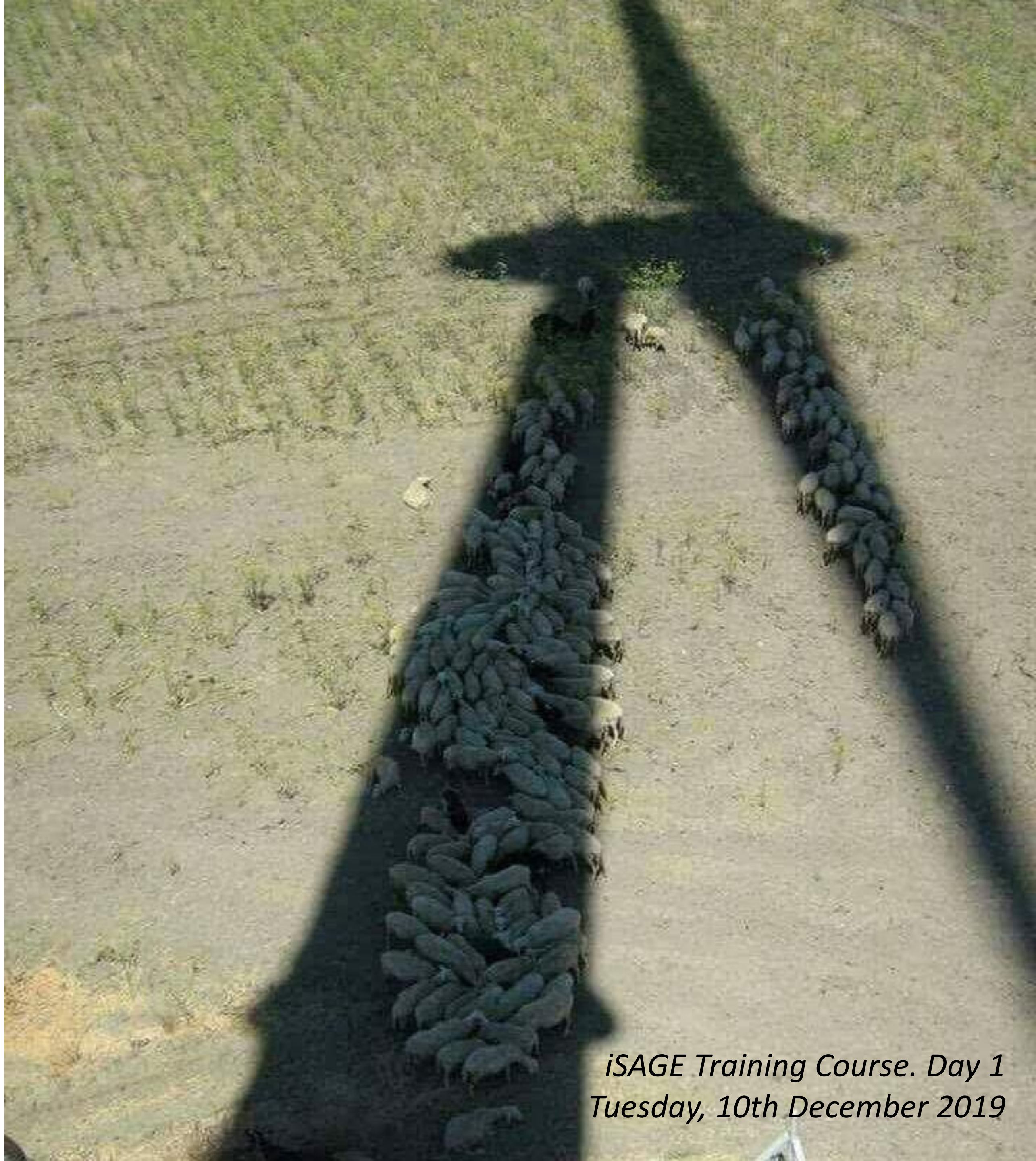


iSAGE Training Course. Day 1
Tuesday, 10th December 2019

Acknowledgements

CIHEAM
IAM ZARAGOZA

AGRAMA

iSAGE

AEMet
Agencia Estatal de Meteorología

ASSAF.ESPAÑA
www.assafe.es

euskalmet
agencia vasca de meteorología

CONFELAC
Confederación de Asociaciones de Criadores de Ovinos de Raza Lacha y Carranzana

IRIAF
Instituto Regional de Investigación y Desarrollo Agroalimentario y Forestal
Castilla-La Mancha

Oviaragón

INIA
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

neiker tecnalia

…and all the people involved in WP5

OUTLINE

1. Introduction. The CC future scenarios in Livestock
2. *Genetic basis of animal response to heat stress*
   - How production (quantality and quality) evolves along the Tª/THI scale. GxE interaction
   - Is there enough genetic variability to select for thermotolerance?
3. *New phenotypes* for the characterization of thermotolerance of sheep and goats.
4. *Breeding strategies*: expected responses in breeding programs to heat tolerance

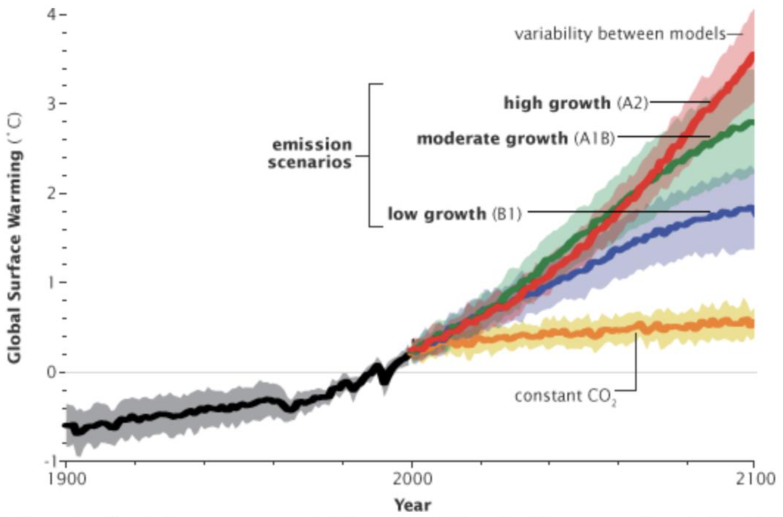
The CC future perspective in Europe

Your results are back. It's climate change. Just how many greenhouse gases have you been consuming?

"Climate Change (CC) includes ***Global Warming*** *(the Earth's rising surface temperatura) and the "side effects" of warming—like melting glaciers, heavier rainstorms, or more frequent drought. Said another way, global warming is one symptom of the much larger problem of climate change"*

Source: NOAA

The CC future perspective in Europe



Model simulations by the Intergovernmental Panel on Climate Change estimate that Earth will warm between two and six degrees Celsius over the next century, depending on how fast carbon dioxide emissions grow. Scenarios that assume that people will burn more and more fossil fuel provide the estimates in the top end of the temperature range, while scenarios that assume that greenhouse gas emissions will grow slowly give lower temperature predictions. The orange line provides an estimate of global temperatures if greenhouse gases stayed at year 2000 levels. (©2007 IPCC WG1 AR-4.)

The **IMPACTS of CC** on Livestock:

- Decrease in quantity and quality of production
- Impaired Reproductive performance
- Increased susceptibility to diseases, new diseases

- Reported Economic losses of 0.5–5% of the total production (St. Pierre et al. 2003; Hammami et al. 2013; Ramon et al. 2016)
- Most of them associated to extreme climate events

- Reduction of economic margins
- Sustainability of production systems compromised

How to deal with CC challenge in livestock?

TRAINING THE SECTOR

- ✏ Ask about their problems and desire goals
- ✏ Explain the consequences of CC, and …
- ✏ … the tools available to deal with them
- ✏ Allow them to make optimal decisions

MITIGATION STRATEGIES

- ❄ Farm facilities design
- ❄ Change in management practices
- ❄ Efficient but usually expensive and labour-consuming

BREEDING & GENETICS

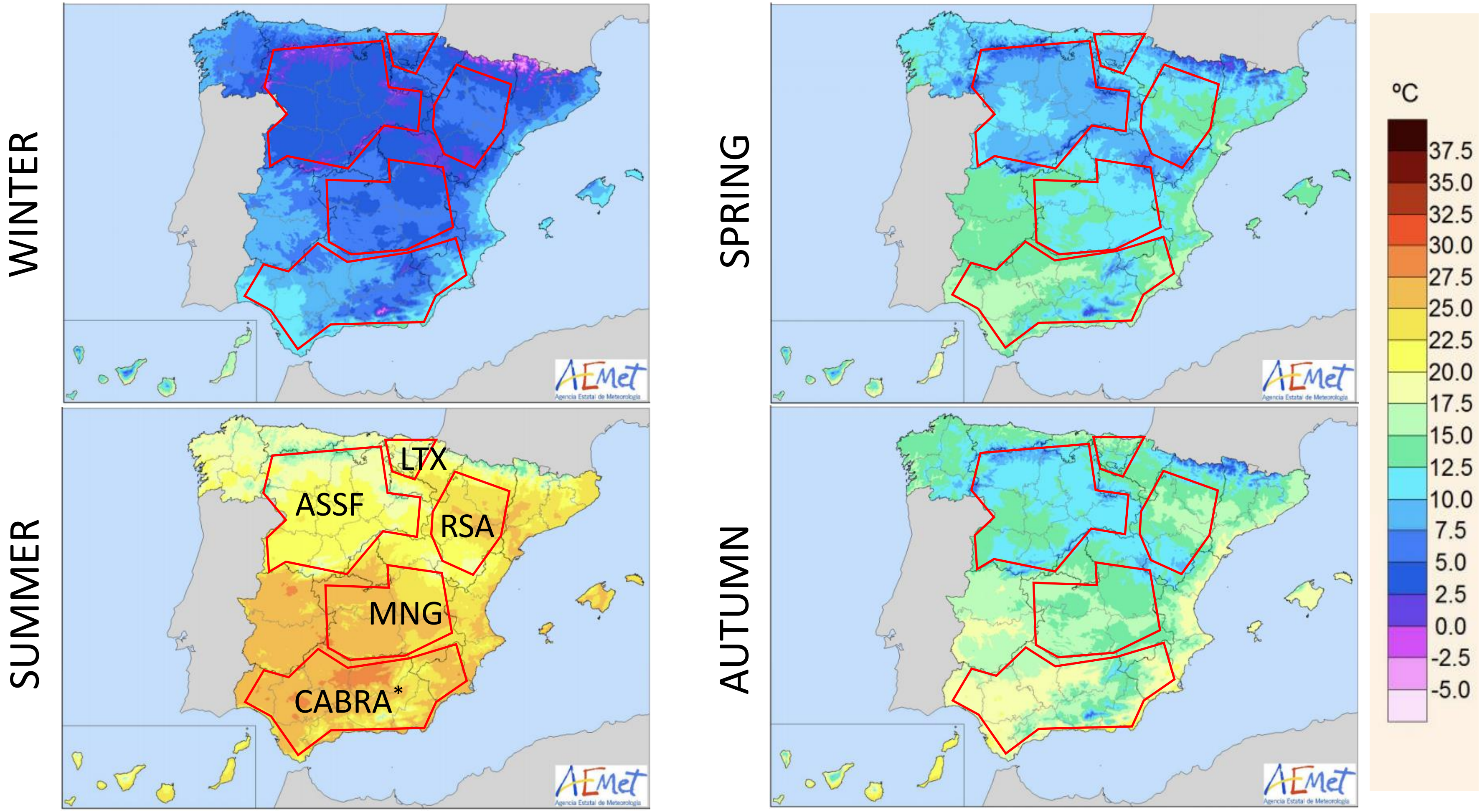
- Genetic basis of thermotolerance
- Correlations with other traits of interest
- Progress is slow but changes are permanent

Genetic approaches to improve sustainability and adapting to climate change

1. Is there evidence of *productive losses associated with adverse climatic conditions*?
2. Are these losses the same for all animals wth/btw breeds/species?
3. What part of the *variability in the response* to thermal stress would be genetically determined?
4. Is it feasible to include *thermotolerance as a breeding goal*?

Climate in Spain

Figure 1. *<u>Thermal maps of average temperature trend along the year (four seasons) in Spain</u>. Data are average daily temperatures for the years 2006 to 2015.*



*__CabrAndalucía (CABRA):__ Murciano-Granadina (CAPRIGRAM), Florida (ACRIFLOR), Malagueña (AECCM), Payoya (ACAPA), Blanca Andaluza (ABLANSE) y Negra Serrana (ANCCA)

Sheep breeds

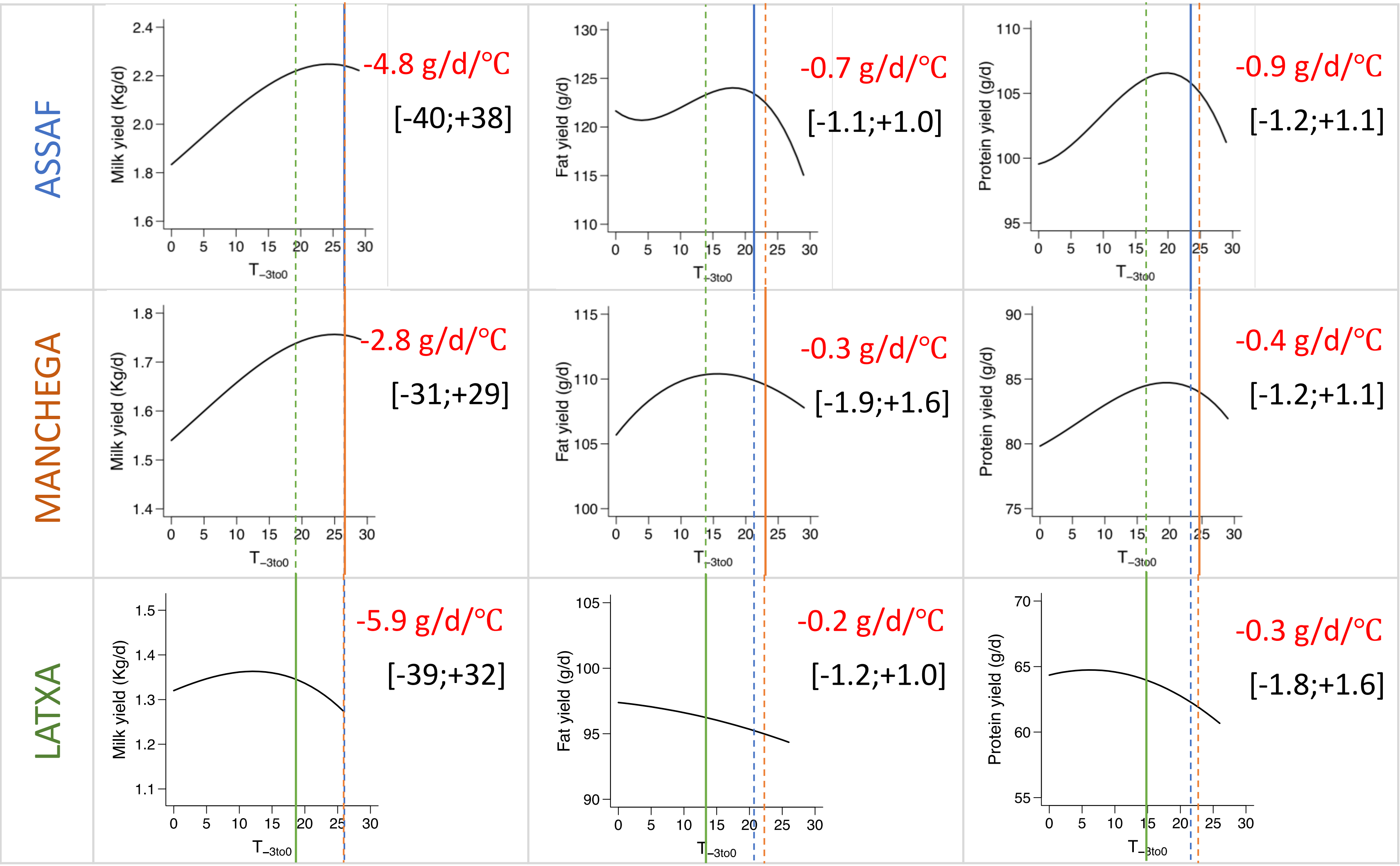
	ASSAF	LATXA	MANCHEGA	RASA ARAGONESA
				
No. ewes	138,345	82,857	181,233	350,927
Milk yield (Kg/d)	2.16	1.4	1.5	-
Fat content (%)	6.1	6.0	7.2	-
Protein content (%)	5.1	5.4	5.8	Total born = 1.60
Fertility (%)	34.0	42.0	41.5	Conception Rate $_{IA}$ = 0.50
Temperature ()	13.6	11.0	14.7	11.7
THI	13.7	10.9	13.9	11.4
Production system	Intensive; 4-6 reproductive groups per year; indoor feeding	Semi-extensive; single reproductive season; grazing & indoor feeding	Semi-intensive; 4-6 reproductive groups per year; grazing, but mainly indoor feeding	Semi-intensive; 3 reproductive groups per year; mainly grazing + supplementation

Goats breeds

	MURCIANA-GRANADINA	FLORIDA	PAYOYA	MALAGUEÑA
				
No. ewes	103,693	24,702	11,611	36,260
Milk yield (Kg/d)	2.07	2.27	1.7	1.9
Fat content (%)	5.11	4.78	4.35	4.8
Protein content (%)	3.49	3.42	3.49	3.4
Fertility (%)	-	-	-	-
Temperature ()	16.5	16.5	16.5	16.5
THI	14.7	14.7	14.7	14.7
Production system	Intensive; 4-6 kidding periods per year; mainly indoor feeding (90% farms)	Intensive; 4-6 kidding periods per year; mainly indoor feeding (90% farms)	Semi-extensive; seasonal kidding; mainly grazing + supplementation (25% feed input)	Semi-intensive; 3-5 kidding periods per year; mainly indoor feeding (75% farms)

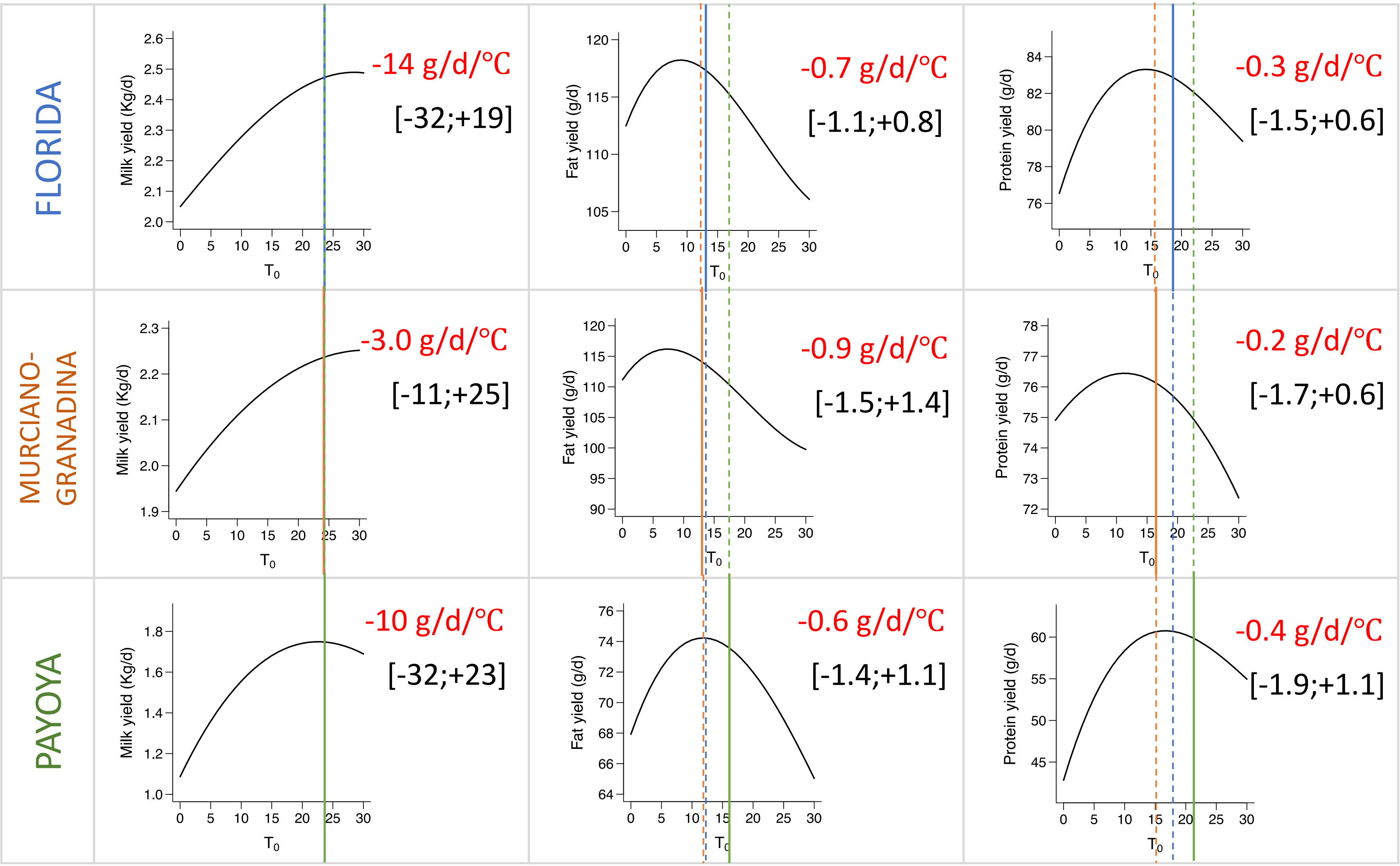
Production response curves in dairy sheep

Figure 2. *<u>Thermal load average response curves for milk traits in dairy sheep</u>. Heat thresholds are represented by lines. Values in red are avg. slopes under heat stress (above thresholds). Values within [brackets] are ranges of individual variation under heat stress.*



Production response curves in goats

Figure 3. *<u>Thermal load average response curves for milk traits in dairy goats</u>. Heat thresholds are represented by lines.* *Values in red are avg. slopes under heat stress (above thresholds). Values within [brackets] are ranges of individual variation under heat stress.*



Fertility response curves in sheep

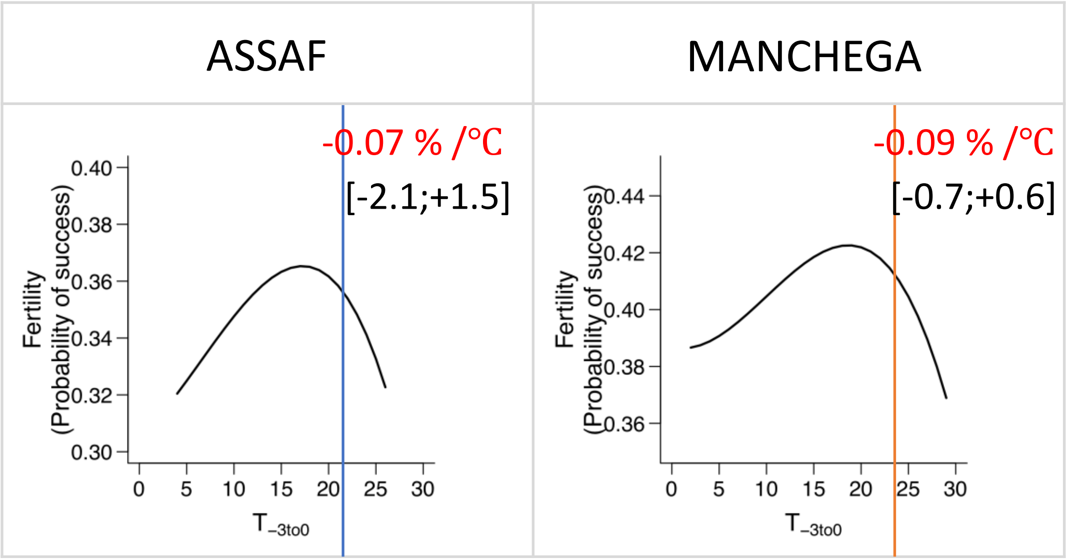


***Figure 4**. <u>Thermal load average response curves for conception rate in dairy sheep</u>. Values in red are avg. slopes under heat stress (above thresholds). Values within [brackets] are ranges of individual variation under heat stress.*

Fertility/Prolificay response curves in meat sheep

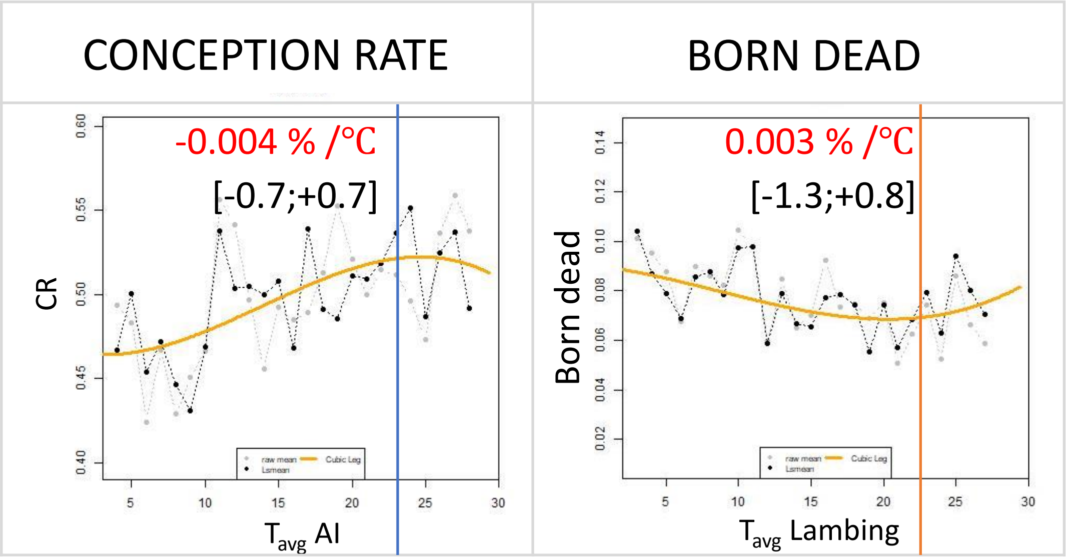


***Figure 5**. <u>Thermal load average response curves for conception rate and total lambs born in meat sheep</u>. Values in red are avg. slopes under heat stress (above thresholds). Values within [brackets] are ranges of individual variation under heat stress.*

Genetic variance along the temperature scale

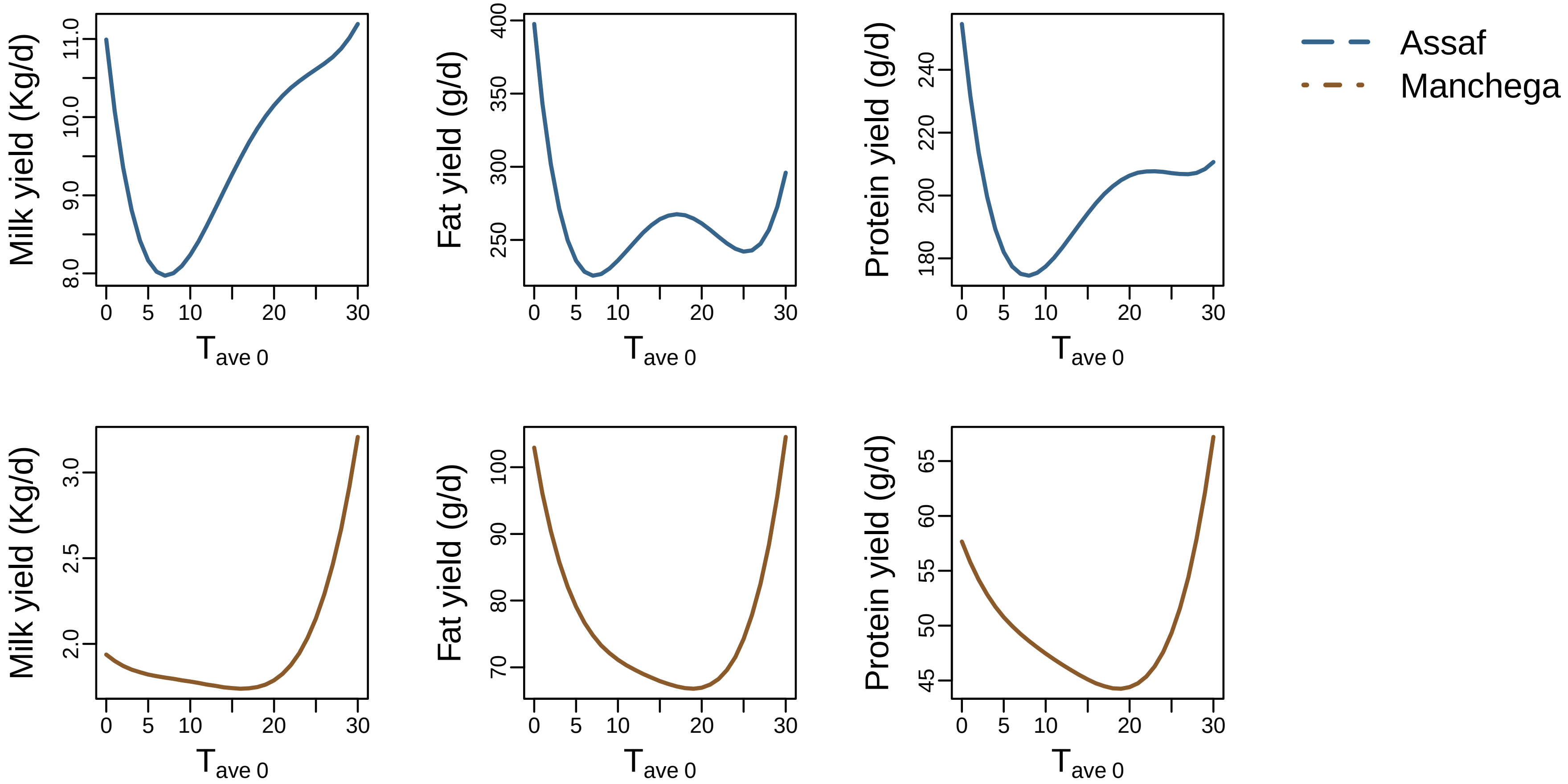


Figure 6. *Genetic variance of milk, fat and protein yields along the temperature (daily average) scale.*

Heritabilities along the temperature scale

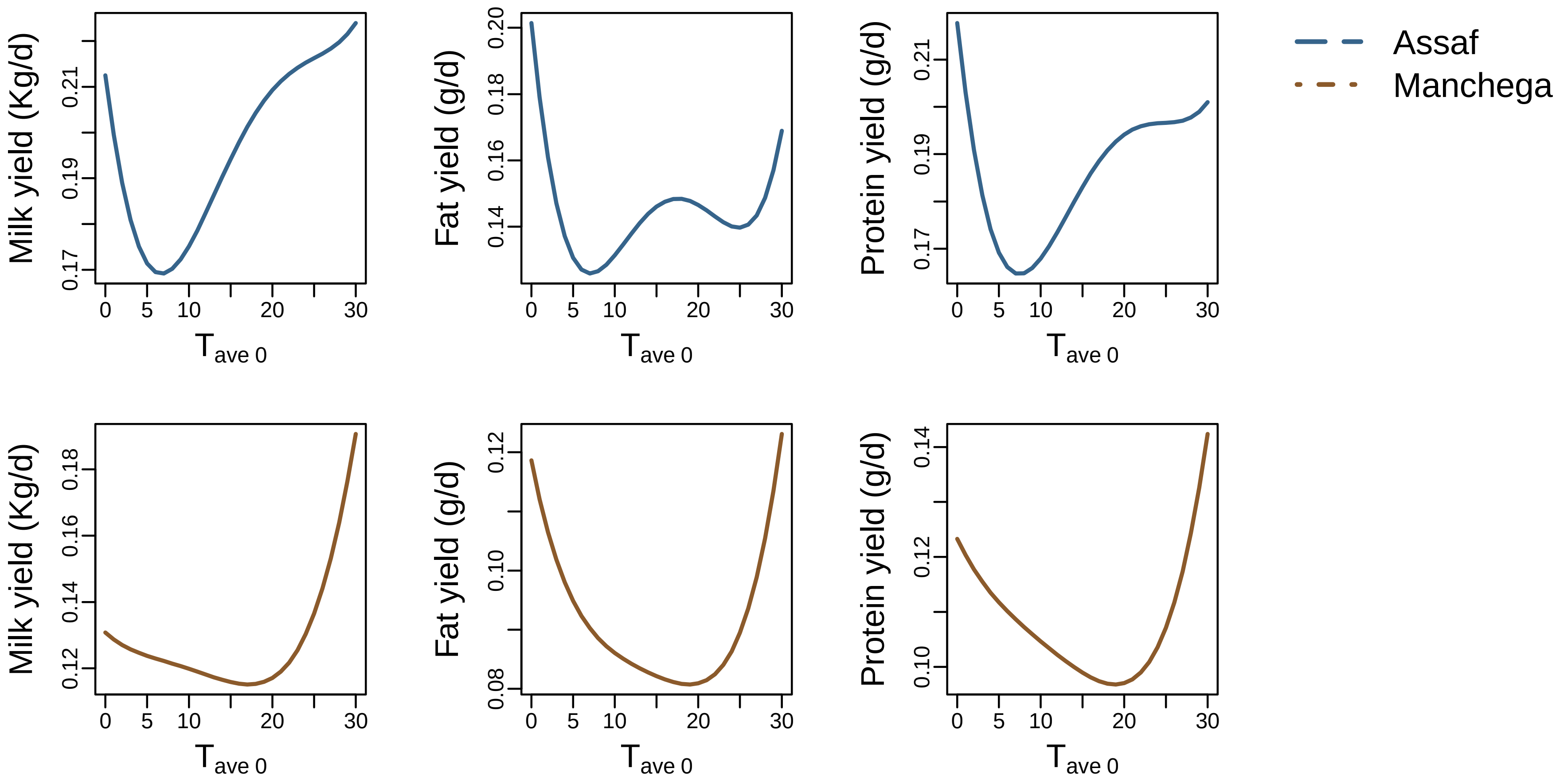


***Figure 7**. Heritabilities of milk, fat and protein yields along the temperature (daily average) scale.*

Genetic correlations between traits

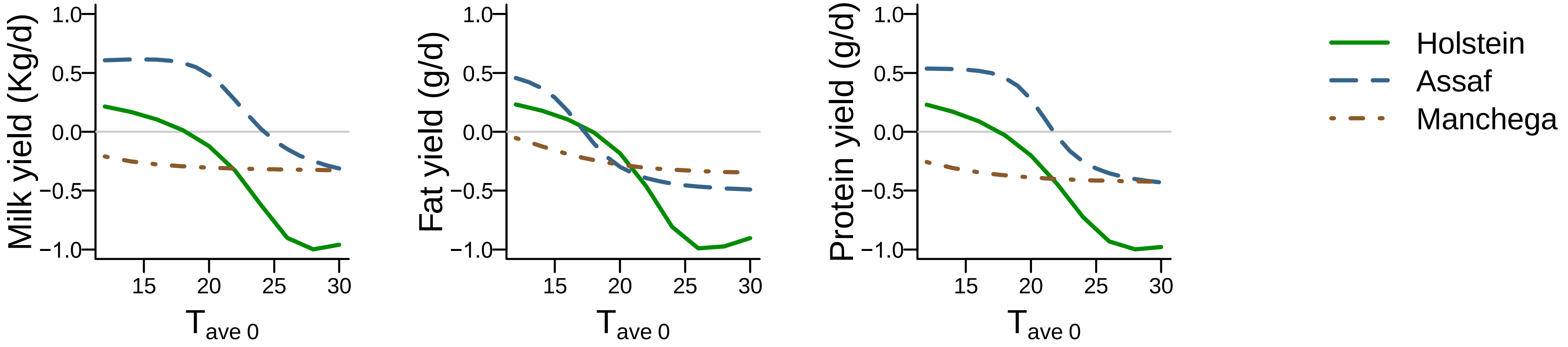


***Figure 8**. <u>Genetic correlations</u> between level of production (intercept) and themotolerance (slope) along the temperature (daily average) scale.*

Genetic responses to different breeding strategies

	Milk yield	Fat yield	Protein yield	HS slope†	Fertility
Scenario 1	100 %	-	-	-	-
Scenario 2	80 %	-	-	20 %	-
Scenario 3	70 %	-	-	30 %	-
Scenario 4	60 %	-	-	40 %	-
Scenario 5	70 %	-	-	0	30 %
Scenario 6	50 %	-	-	25 %	25 %
Scenario 7	60 %	-	-	25 %	15 %

Table 3. Possible Breeding Scenarios including thermtolerance (heat stress slope) as selection objective

† HS slope for protein yield

Genetic responses to different breeding strategies

	Milk	Fat	Protein	HS slope[†]	Fertility*	% loss +1 °C	% loss +1SD
Initial	1.30	84.20	67.90	-0,70	0,42	-	-
S1 (100/0/0)	1.77	114.74	92.50	-1,35	0,34	-2,64%	-14,13%
S2 (80/20/0)	1.72	112.82	90.65	-0,74	0,37	-0,18%	-7,90%
S3 (70/30/0)	1.69	109.60	88.67	-0,40	0,38	1,44%	-4,37%
S4 (60/40/0)	1.59	103.91	84.70	0,27	0,39	3,77%	1,09%
S5 (70/0/30)	1.72	112.36	90.73	-1,22	0,47	-2,28%	-13,02%
S6 (50/25/25)	1.56	103.43	83.82	-0,01	0,44	4,33%	-0,12%
S7 (60/25/15)	1.67	108.18	87.6†8	-0,32	0,39	1,92%	-3,53%

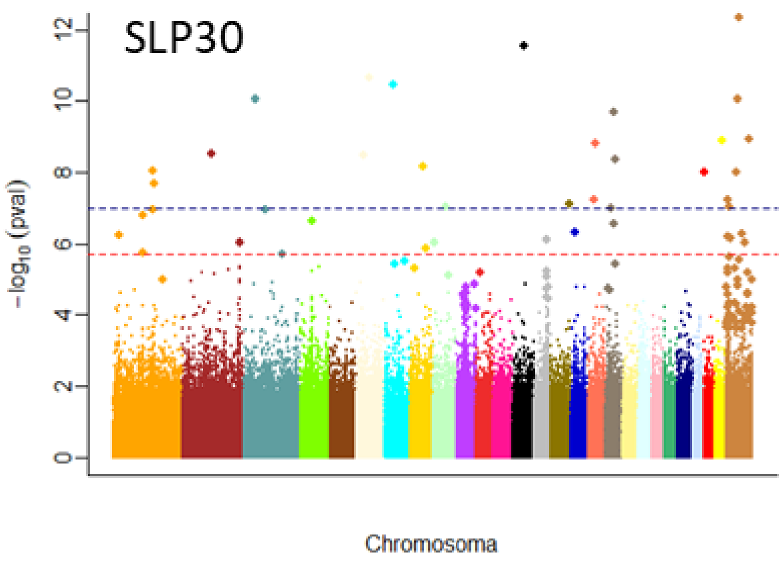
Table 4. Estimated responses to different breeding scenarios. Values within each scenario are average responses after 15 generations and 20 replicates.

† HS slope for protein yield

* **NOTE:** fertility rates have not been considered in the estimation of losses

Going further: Genomics (and other omics)

ASSAF



MANCHEGA

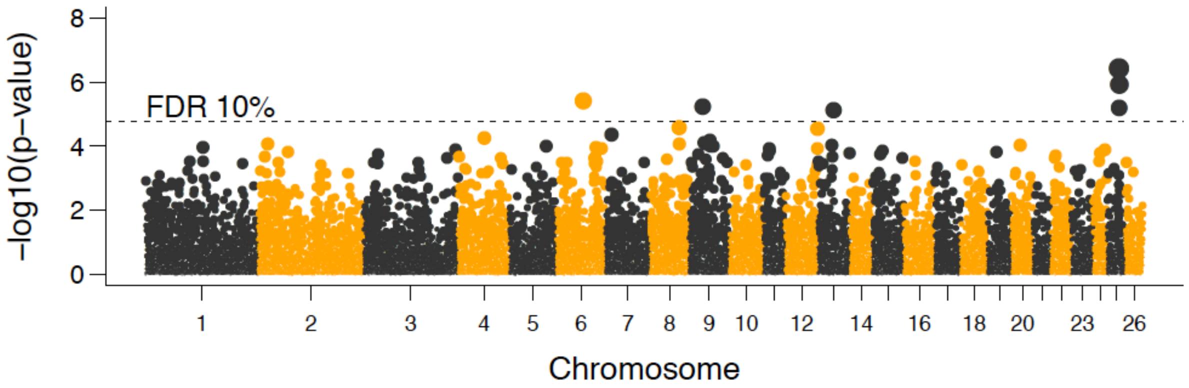
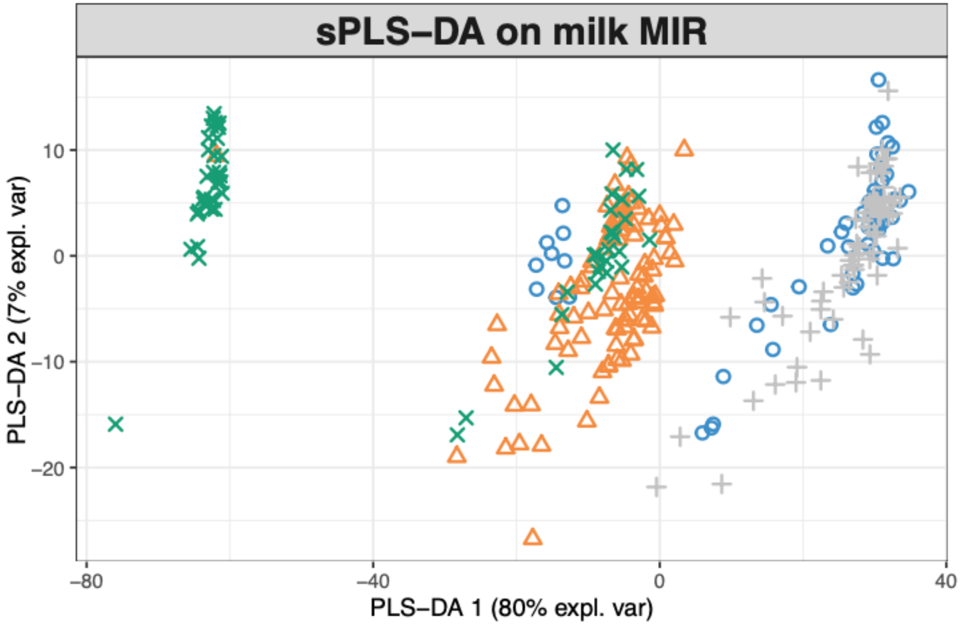


Figure 9. *Manhattan plots of GWA Studies of thermotoletance in the Assaf (HS slope at 30 ºC for protein yieid) and Manchega (HS slope at 25ºC for fat yield) dairy sheep breeds*

New phenotypes: MIR data



PLS-DA Loadings

	Comp 1	Comp 2
○ Comfort & primiparous	0.382	0.260
△ Heat & primiparous	-0.193	-0.761
+ Comfort & multiparous	0.540	0.028
× Heat & multiparous	-0.724	0.594

***Figure 10**. First two components of the PLS-DA analysis from mid-infrared spectra of sheep milk in relation to the physiological status (primiparous vs. multiparous) and the presence or absence of environmental stressors (comfort vs. heat stress).*

Conclusions

1. ***Genetic selection*** is presented as a promising tool for ***improving thermotolerance*** of animals, and its benefits will be larger in combination with mitigation strategies and educational work.
2. There is ***room for improving thermotolerance/resilience*** while maintaining production efficiency
3. Suitability of ***slope of decay above heat stress threshold as selection criteria***
4. ***Negative correlations between thermotolerance (HS slopes) with production*** traits implies that we have to combine these traits appropriately when defining breeding strategies
5. A **selection index including production traits, fertility and thermotolerance** has been showed as an appropriate breeding strategy within the CC framework.