Agris
Agentzia pro sa chirca in agricoltura
Agenzia regionale per la ricerca in agricoltura

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Transgenerational effects of heat stress in dairy sheep

M.G. Usai, S. Casu, S.L. Salaris, T. Sechi[1], S. Miari, G. Mulas and A. Carta

AGRIS Sardegna, Research Unit: Genetics and Biotecnologies – Sassari, Italy

Agris
Agentzia pro sa chirca in agricoltura
Agenzia regionale per la ricerca in agricoltura

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

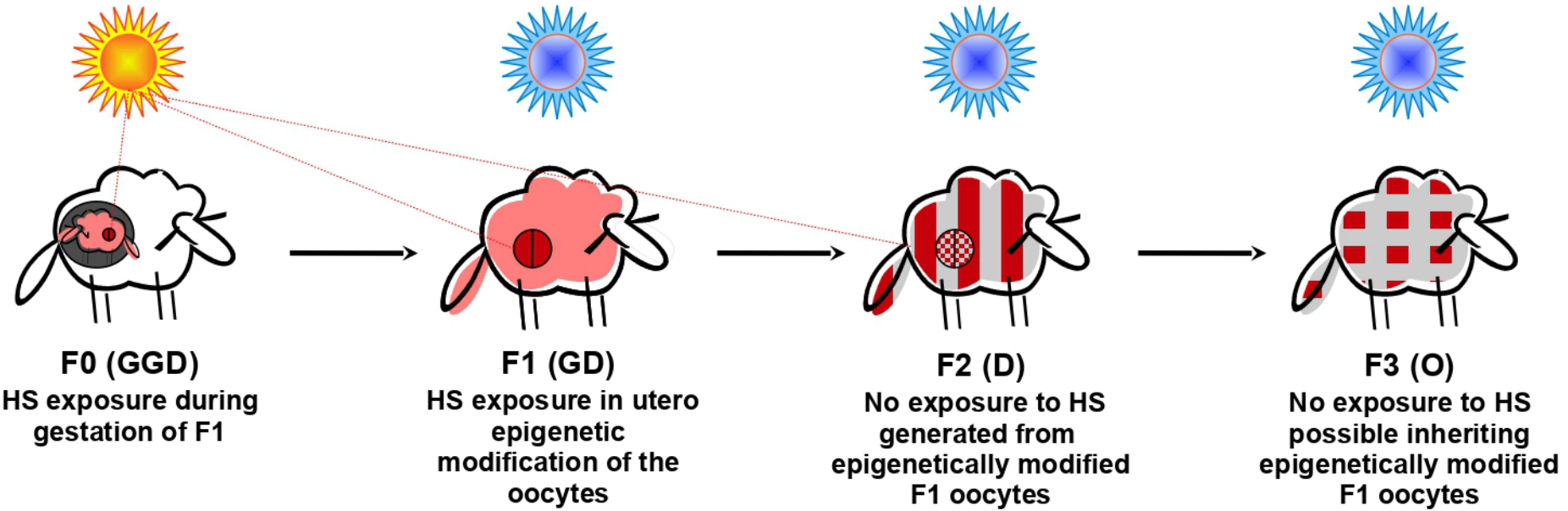
75th EAAP Annual Meeting, 1/5 September 2024, Florence Italy

Introduction

Climate change and **global warming** are leading to a progressive increase in the occurrence of heat stress (**HS**) in livestock. Besides the negative effects on production and reproduction traits due to direct exposure to **HS**, there is the possibility that these effects could be transmitted through **transgenerational** way to the next generations.

Introduction

Transgenerational effects → non-genetic environmental influences that are passed from ancestral generations to offspring



Introduction

Dairy cattle → some studies showed that the effect of **F1** cows' birth month, detected on the breeding values of **F3** granddaughters, is likely due to **HS** suffered during the pregnancy.

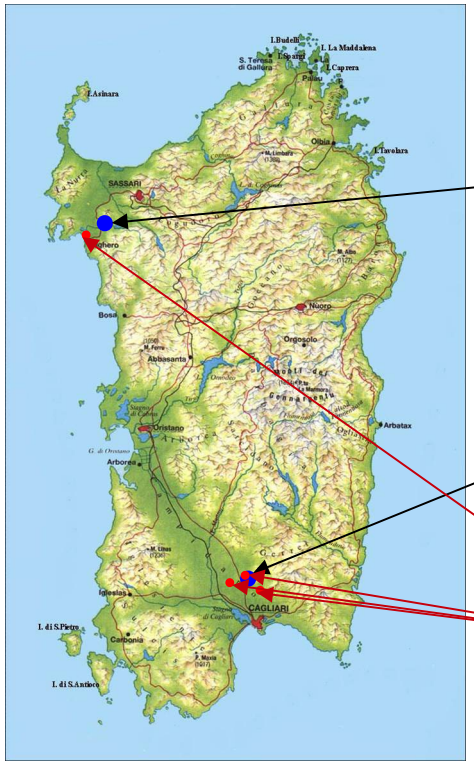
Dairy sheep → No studies on **transgenerational** effects of **HS**.

Aim of the study

In the framework of **SCALA-MEDI** project, the present study aims to investigate the **transgenerational effect** of **HS** on **milk yield** of **Sarda** dairy sheep by analyzing effects on Offspring performances of **HS** suffered by Dam, maternal Grand-Dam and Great-Grand-Dam during their Gestation.

Materials & Methods

Geographic Location



Bonassai - Sassari (SS)
40°40'19.09"N, 8°21'55.78"E; ASL 35 m
22% of the investigated pregnancies

Ovile Sardo - Monastir (CA)
39°21'4.89"N, 9°04'17.66"E; ASL 90 m
78% of the investigated pregnancies
100% of the phenotyped/genotyped ewes

Meteorological stations

Agris
Agentzia pro sa chirca in agricoltura
Agenzia regionale per la ricerca in agricoltura

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Materials & Methods

Ovile Sardo Population (FRP)

One flock → ~900 milking ewes (replacement ~25%)

Replacements → HB rams X FRP ewes.

So far, ~ 5,000 ewes generated by 220 rams.

ALL ewes and sires genotyped with → *Illumina Inc. OvineSNP50 Beadchip*

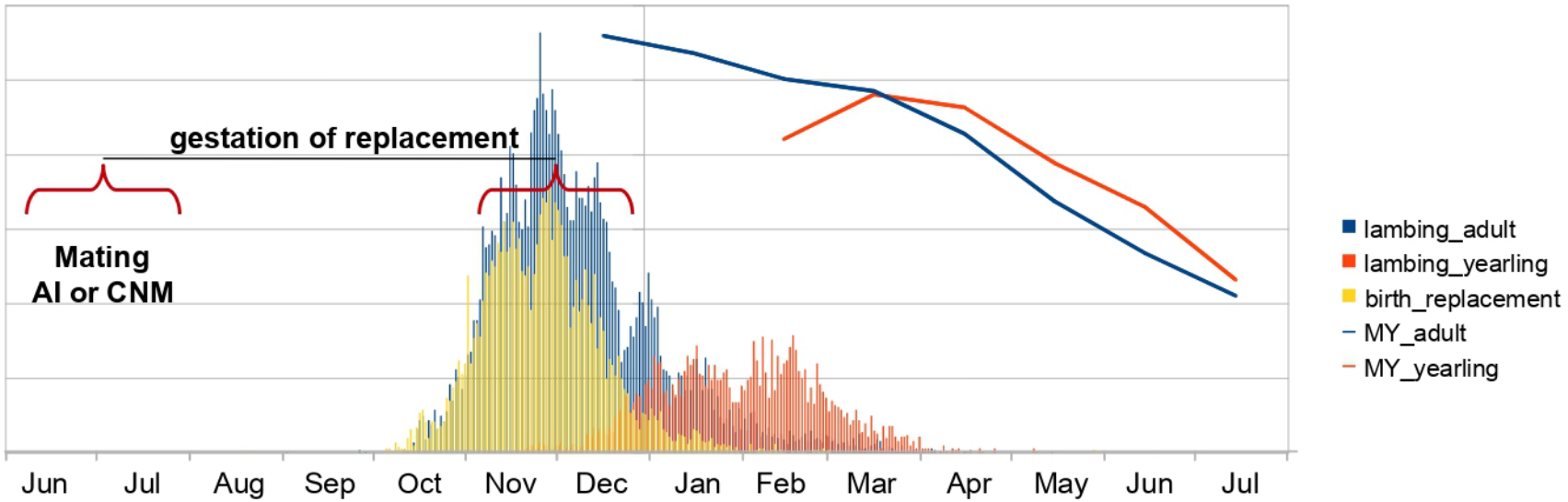
FRP ewes → routinely recorded for functional, health and production traits

Farming system → that commonly applied in commercial Sardinian flocks

Materials & Methods

Sardinian Farming System

Seasonal breeding



Materials & Methods

Milk Yield Data

16,249 MY lactations recorded in the experimental farm “Ovile Sardo” (**South**) between **2000** and **2022** of **4,940** genotyped ewes born from **1999** to **2021** were used to estimate Genomic Breeding Values (**GEBV**) by an animal model:

$$\boldsymbol{y = Xb + Zu + Wp + e}$$

$\boldsymbol{y}$ → 16,249 lactation records; $\boldsymbol{b}$ → fixed effects; $\boldsymbol{u}$ → 7,666 breeding values; $\boldsymbol{p}$ → 4,940 random permanent environmental effects; $\boldsymbol{e}$ → 16,249 random residuals; $\boldsymbol{X}$, $\boldsymbol{Z}$ & $\boldsymbol{W}$ → incidence matrices

$\boldsymbol{u} = \mathbf{GEBV} \sim N(0, \mathbf{G}\sigma_g^2)$, $\mathbf{G}$ → Genomic relationship Matrix σ_g^2 → genetic variance

Materials & Methods

Pregnancies Data

A total of **6,153** pregnancies from **1982** to **2021** were investigated.

Ovile Sardo (**South**) → **4,783** pregnancies
Bonassai (**North**) → **1,370** pregnancies

~ **80%** of ewes' birth occurred between **November 1st** and **December 15st**

HS exposure was analysed in:
1st/third → 101-150 days before lambing
2nd/third → 51-100 days before lambing
3rd/third → 1-50 days before lambing

Materials & Methods

Climatic Data

From **1981** to **2021** daily recording of ambient maximum temperature (**T**) and average relative humidity (**RH**)

Meteorological stations :
Bonassai (SS) → 1 station (~ 6.0 Km apart)
Ovile Sardo (CA) → 3 stations (1 inside the farm; 2 ~ 9.0 Km apart)

Temperature-Humidity Index (THI):

$$THI = \{T - [0.55 \times (1 - RH)] \times (T - 14.4)\}$$

Measures of **HS** in a given period:
THImd → average THI
THId23 → count of days where THI >=23
THIc23 → count of THI units >=23

Materials & Methods

Data analysis

For each of the three considered gestation stages, **GEBVs** of **4,758** lactating Offspring (**O**) for which pregnancies of Dam(**D**), GrandDam(**GD**) and GreatGrandDam(**GGD**) were available, were analyzed with the following linear model:

$$GEBV_i = GEBV_{si} b_s + HS_{Di} h_D + HS_{GDi} h_{GD} + HS_{GGDi} h_{GGD} + e_i$$

$GEBV_i$ → GEBV of offspring i; b_s → linear effect of sire's GEBVs; h → linear effects of **HS** suffered by **D**, **GD** and **GGD** during the given gestation stage; e_i → residuals; $GEBV_{si}$ → GEBV of offspring i sire; **HS** → measure of **Heat Stress** (THImd; THId23; THIc23) recorded during the given pregnancy stage of **D**, **GD** and **GGD**.

For all the estimated linear effects (H0:β=0) → t-test [*glm function R*]

Results

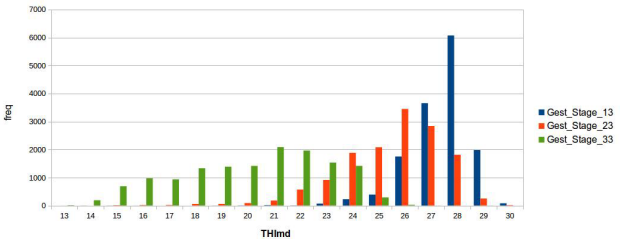
Variance Components MY

Estimates	MY (SE)
σ^2_p	484 (26)
σ^2_g	690 (46)
σ^2_e	863 (11)
σ^2_{tot}	2037 (39)
r_p	0.58 (0.01)
h^2	0.34 (0.02)

Results

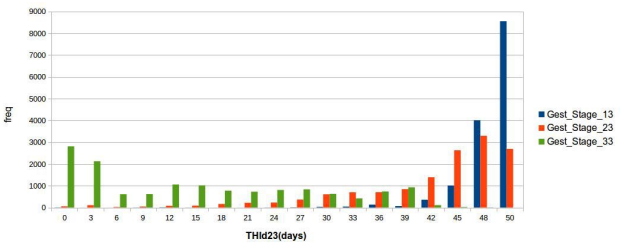
Climatic data

THImd



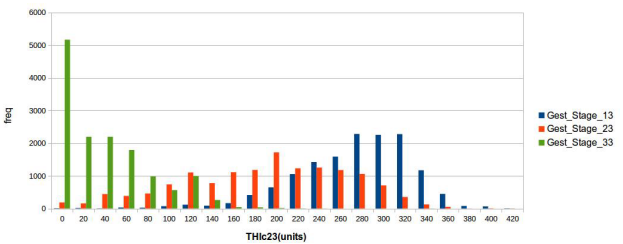
G. stage	Mean	St.Dev	r(x,1/3)	r(x,2/3)	r(x,3/3)
1/3	27	1	1.00	0.02	-0.20
2/3	26	2	0.02	1.00	0.82
3/3	20	3	-0.20	0.82	1.00

THId23



G. stage	Mean	St.Dev	r(x,1/3)	r(x,2/3)	r(x,3/3)
1/3	49	4	1.00	0.22	-0.14
2/3	42	10	0.22	1.00	0.61
3/3	15	13	-0.14	0.61	1.00

THIc23



G. stage	Mean	St.Dev	r(x,1/3)	r(x,2/3)	r(x,3/3)
1/3	277	58	1.00	-0.14	-0.44
2/3	191	79	-0.14	1.00	0.69
3/3	39	40	-0.44	0.69	1.00

Results

Climatic data (THImd)

Estimates	1st/third		2nd/third		3rd/third	
	effect	signif.	effect	signif.	effect	signif.
intercept	-15.772		23.397	***	19.639	***
b_s	0.509	***	0.515	***	0.515	***
h_D	0.296		-0.349	*	-0.251	**
h_{GD}	0.234		-0.443	***	-0.410	***
h_{GGD}	-0.032		-0.204		-0.413	***

Signif. Codes: *** <0.001; ** <0.01; * <0.05

Results

Climatic data (THId23)

Estimates	1st/third		2nd/third		3rd/third	
	effect	signif.	effect	signif.	effect	signif.
intercept	2.755		5.453	**	1.582	**
b_s	0.511	***	0.515	***	0.511	***
h_D	0.093		-0.052		-0.058	**
h_{GD}	-0.088		-0.079	**	-0.084	***
h_{GGD}	-0.106		-0.049	*	-0.096	***

Signif. Codes: *** <0.001; ** <0.01; * <0.05

Results

Climatic data (THIc23)

Estimates	1st/third		2nd/third		3rd/third	
	effect	signif.	effect	signif.	effect	signif.
intercept	-6.5387	**	2.6510	*	0.5888	**
b_s	0.5082	***	0.5151	***	0.5106	***
h_D	0.0085		-0.0091	**	-0.0151	*
h_{GD}	0.0075		-0.0117	***	-0.0241	***
h_{GGD}	0.0001		-0.0040	*	-0.0278	***

Signif. Codes: *** <0.001; ** <0.01; * <0.05

Conclusions

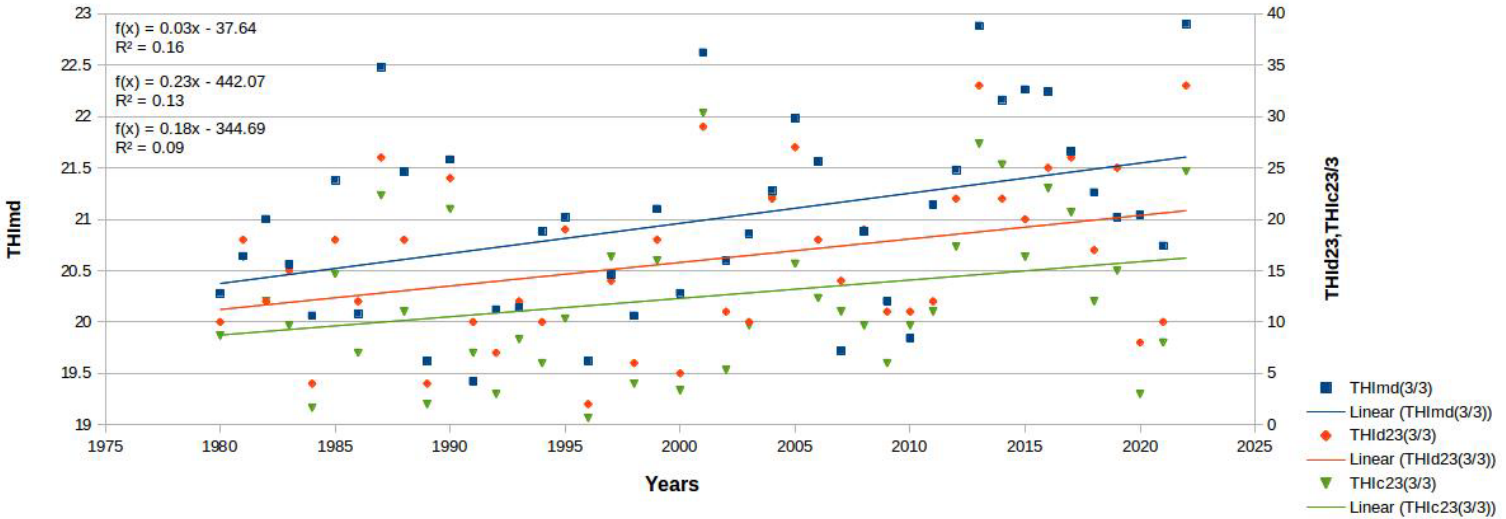
Results provide evidence of transgenerational effects of HS through the maternal line in dairy sheep.

Results suggest that the HS suffered by Great-Grand-Dams during the last 50 days of pregnancy causes adverse effects on Milk production of their Grand-Daughters and Great-Grand-Daughters.

The proportion of genetic variances explained by the transgenerational effect of HS is moderate (~1 %)...SO FAR!!

Conclusions

What in the future?



Increased incidence of HS due to global warming → implement further mitigation strategies and studies on the genetic adaptability of the animals.

This study was realized in the framework of the EU funded project

"*Improving sustainability and quality of Sheep and Chicken production by leveraging the Adaptation potential of LocAl breeds in the MEDIterranean area*" (SCALA-MEDI)

Agris
Agentzia pro sa chirca in agricoltura
Agenzia regionale per la ricerca in agricoltura

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Thanks for your kind attention!!