Re-Livestock
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# Are the most productive, the less thermotolerant animals in low input beef cattle populations? The case of the Avileña-Negra Ibérica beef cattle breed.

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# Introduction

- Losses of beef cattle industry due to climate change are increasing (.
- Low cow-calf production systems are extensive.

- No many studies in beef cattle,
  Results on trades-off between tolerance and production level are heterogeneus (Santana et al., 2015; Bradford et al, 2018)
- Local breeds are supposed to be well adapted to challenging environments, however,such ability needs to be characterized.

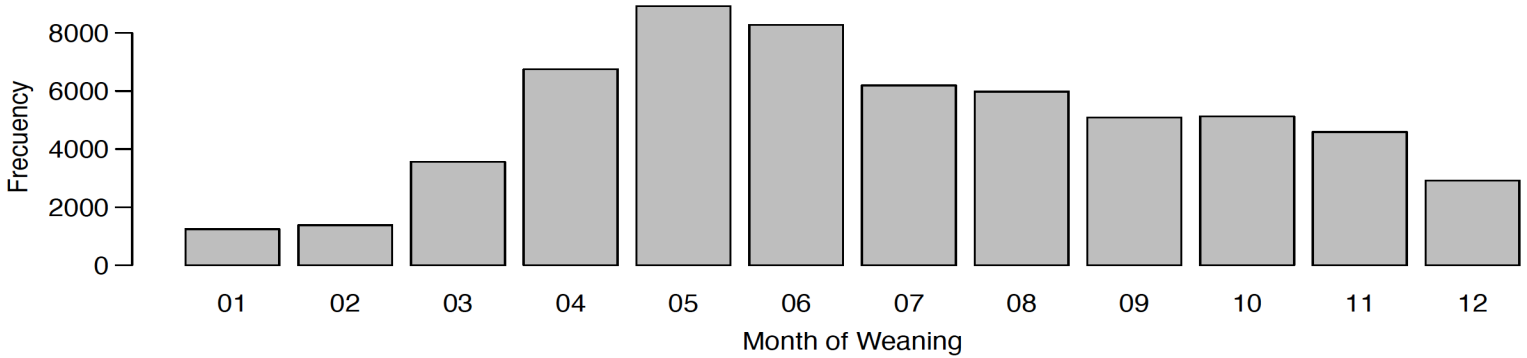
# Objectives

1.- To characterize the impact of **Temperature** on the two most relevant traits in a **cow-calf production system** up to now : **WWT and Fertility**

2.- To evaluate the **association between production and thermotolerance** by using WWT under different models.

# Data: WWT (N=60,008) and Thermal Loads definitions

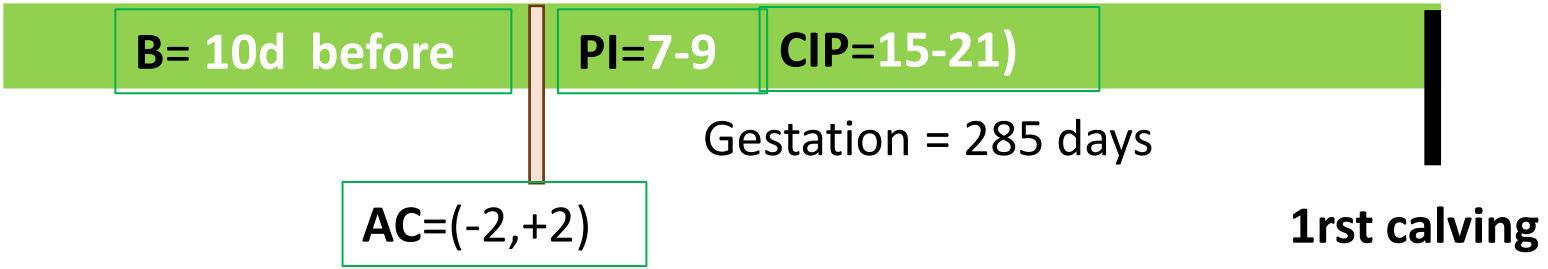
| Mean | sd | CV | Min | P10 | P25 | P50 | P75 | P90 | Max |
|---|---|---|---|---|---|---|---|---|---|
| **224** | 44.6 | 0.2 | 89 | 170 | 195 | 220 | 251 | 283 | 400 |




| | Tmax0 | Tmax5 | Tmax10 | Tmax20 | Tmax30 | Tave0 | Tave5 | Tave10 | Tave20 | Tave30 | Tmin0 | Tmin5 | Tmin10 | Tmin20 | Tmin30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 21.6 | 21.5 | 21.5 | 21.4 | 21.3 | 15.2 | 15.2 | 15.1 | 15.1 | 15.0 | 8.9 | 8.9 | 8.8 | 8.8 | 8.7 |
| sd | 8.7 | 8.2 | 8.0 | 7.7 | 7.5 | 7.2 | 6.8 | 6.7 | 6.5 | 6.4 | 6.3 | 5.8 | 5.7 | 5.5 | 5.4 |
| Min | -6.0 | -3.0 | -2.3 | -0.1 | 0.4 | -8.0 | -5.0 | -4.2 | -2.9 | -2.1 | -15.0 | -11.7 | -9.0 | -8.8 | -8.6 |
| P25 | 14.9 | 15.0 | 15.0 | 15.3 | 15.2 | 9.8 | 9.8 | 9.8 | 9.7 | 9.7 | 4.2 | 4.6 | 4.5 | 4.5 | 4.5 |
| Med | 22.0 | 21.8 | 21.6 | 21.5 | 21.4 | 15.5 | 15.3 | 15.3 | 15.1 | 15.0 | 9.1 | 9.1 | 8.9 | 9.0 | 8.8 |
| P75 | 28.5 | 28.1 | 28.1 | 27.9 | 27.6 | 21.0 | 20.6 | 20.5 | 20.4 | 20.2 | 13.6 | 13.2 | 13.2 | 13.0 | 12.9 |
| Max | 45.5 | 42.8 | 42.5 | 40.4 | 40.0 | 33.5 | 33.2 | 33.5 | 31.8 | 31.5 | 27.0 | 26.0 | 24.5 | 23.9 | 24.5 |

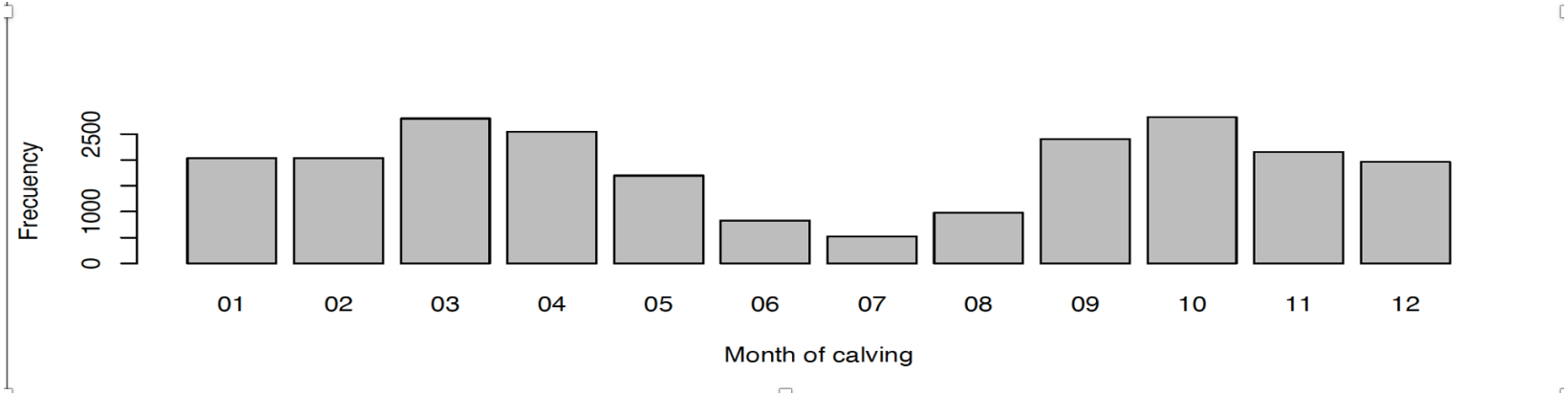
# Data: Age at first calving (AFC=22,682) and thermal loads definitions

| Mean | sd | CV | Min | P10 | P25 | P50 | P75 | P90 | Max |
|---|---|---|---|---|---|---|---|---|---|
| **972** | 150 | 0.2 | 620 | 760 | 854 | 982 | 1090 | 1162 | 1281 |




**B=**average 10 d. before conception**; AC:** arround conception**; PI=**pre-implantation; **CIP=**complete implantation and placentation.

# Data: Age at first calving (AFC=22,682) and thermal loads




| | Tmax B | Tmax AC | Tmax PI | Tmax CIP | Tave B | Tave AC | Tave PI | Tave CIP | Tmin B | Tmin AC | Tmin PI | Tmin CIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Men** | 17.9 | 18.1 | 18.4 | 18.9 | 12.0 | 12.1 | 12.4 | 12.8 | 6.1 | 6.2 | 6.3 | 6.7 |
| **sd** | 8.2 | 8.6 | 8.6 | 8.8 | 6.9 | 7.1 | 7.2 | 7.4 | 5.9 | 6.2 | 6.2 | 6.3 |
| **Max** | 41.6 | 42.8 | 42.7 | 41.9 | 31.6 | 32.6 | 33.6 | 33.7 | 23.7 | 25.3 | 24.8 | 27.9 |
| **P75** | 24.7 | 25.3 | 26.0 | 26.7 | 17.2 | 17.8 | 18.3 | 18.9 | 10.2 | 10.5 | 10.8 | 11.3 |
| **P50** | 16.3 | 16.5 | 16.8 | 17.7 | 11.0 | 11.1 | 11.3 | 11.9 | 5.5 | 5.7 | 5.7 | 6.1 |
| **P25** | 11.2 | 11.1 | 11.3 | 11.4 | 6.5 | 6.4 | 6.5 | 6.6 | 1.8 | 1.6 | 1.7 | 1.8 |
| **Min** | -1.3 | -5.7 | -2.0 | -2.7 | -5.1 | -8.4 | -5.9 | -5.7 | -14.3 | -16.7 | -13.7 | -11.9 |

# Methods: Population response

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Average population response to the impact of heat stress on WWT and AFL were obtained

$$y_{ijk} = EE_i + \sum_{j=0}^{q=3} b_j x_j + e_{ijk}$$

where, $EE_i$ contains effects not related to heat loads.

$x_j$ contains the heatloads described before for each trait

$b_j$ represents the overall regresion coefficient to descibe the effect on WWT and AFL of different heat loads.

**Population Response = Thresholds of Tª to observe the effects of Tª**

**Slopes** (Segmented package of R (Muggeo, 2008)

# Results: WWT

## Thresholds of Tª bellow (CS) or above (HS) the WWT is affected

| | | Lags | | | | |
|---|---|---|---|---|---|---|
| Thermal Loads | Interval | 0 | 5 | 10 | 20 | 30 |
| Tave | CS | 1.6 | 4.4 | 4.6 | **5.3** | 6.3 |
| | HS | 25.3 | 25.6 | 26.3 | **24.6** | 24.3 |
| Tmax | CS | - | 8.6 | 8.6 | 9.3 | 9.3 |
| | HS | - | 33.4 | 33.5 | 31.5 | 31.4 |
| Tmin | CS | - 4.3 | -2.2 | -0.6 | -0.4 | - |
| | HS | 19.3 | 18.6 | 18.4 | 17.6 | - |

# Results: WWT

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**Slopes of decay due to heat stress and impact on the loss of Kgs.**

| | | Lag | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 5 | 10 | 20 | 30 |
| Tave | Slope (kg/Cº) | -0.263 | 0.329 | -0.190 | **-0.522** | -0.55 |
| | Loss (kg) | 2.2 | 2.7 | 1.6 | **3.5** | 3.6 |
| Tmax | Slope (kg/Cº) | - | - | - | -0.136 | -0.20 |
| | Loss (kg) | | - | - | 1.3 | 1.8 |
| Tmin | Slope (kg/Cº) | -0.886 | -0.108 | -0.505 | -0.505 | -0.91 |
| | Loss (kg) | 8.9 | 0.8 | 3.8 | 3.5 | 1.0 |

# Results: AFC

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## Thresholds of Tª bellow (CS) or above (HS) the AFC is affected

| Thermal Loads | Interval | B | AC | PI | CIP |
|---|---|---|---|---|---|
| Tave | CS | **2.3** | 1.0 | 0.6 | -0.5 |
| | HS | **23.4** | 22.3 | 23.6 | 23.4 |
| Tmax | CS | 6.7 | 5.6 | 6.7 | 5.5 |
| | HS | 31.5 | 32.4 | 32.4 | 31.4 |
| Tmin | CS | - 4.4 | 9.4 | 11.4 | - |
| | HS | 15.7 | 18.4 | 19.0 | - |

**B=**average 10 d. before conception**; AC:** arround conception**; PI=**pre-implantation; **CIP=**complete implantation and placentation.

# Results: AFC

## Slopes of increase of AFC due to heat stress and absolute increase.

| | | B | AC | PI | CIP |
|---|---|---|---|---|---|
| Tave | Slope (d/Cº) | 3.6 | 2.1 | 1.7 | 1.3 |
| | Δ(d) | 31 | 20 | 18 | 14 |
| Tmax | Slope (d/Cº) | 4.2 | 2.7 | 1.4 | 1.2 |
| | Δ(d) | 40 | 29 | 13 | 15 |
| Tmin | Slope (d/Cº) | 3.9 | 1.3 | 1.9 | - |
| | Δ(d) | 30 | 12 | 19 | - |

**B=**average 10 d. before conception**; AC:** arround conception**; PI=**pre-implantation; **CIP=**complete implantation and placentation.

# Methods: Individual level.

## WWT General Model

$$y_{ijklmn} = EE_i + \sum_{j=0}^{q=1} b_j x_j + \sum_{j=0}^{q=1} d_{kj} x_j + \sum_{j=0}^{q=1} m_{lj} x_j + \sum_{j=0}^{q=1} pe_{mj} x_j + e_{ijklmn}$$

$x_o=1$; $x_1$=T-To , To=heat stress threshold

$$G_0 = \begin{bmatrix} \sigma_d^2 & \sigma_{d,slpd} & \sigma_{d,m} & \sigma_{d,slpm} \\ \sigma_{slpd,d} & \sigma_{slpd}^2 & \sigma_{slpd,m} & \sigma_{slpd,slpm} \\ \sigma_{m,d} & \sigma_{m,slpd} & \sigma_m^2 & \sigma_{m,slpm} \\ \sigma_{slpm,d} & \sigma_{slpm,slpd} & \sigma_{slpm,m} & \sigma_{slpm}^2 \end{bmatrix}$$

# Results: Estimates of (co) variance components for Tave20

| | M0 | M1 | M2 | M3 | M4 | M5 |
|---|---|---|---|---|---|---|
| Var(d) | 215.1 | 252.2 | 115.8 | - | 266.2 | 143.1 |
| **Var($slp_d$)** | - | 11.1 | 5.8 | - | 7.6 | 6.3 |
| **Cov(d, $slp_d$)** | **-** | **-27.7** | **-12.6** | **-** | **-20.6** | **-13.8** |
| **Var(m)** | 124.1 | 129.09 | 39.34 | 61.1 | 124.1 | 129.1 |
| **Var($slp_m$)** | - | 1.3 | 0.1 | 1.1 | - | - |
| **Cov(m, $slp_m$)** | **-** | **-3.4** | **1.97** | **1.5** | **-** | **-** |
| **Cov(d,m)** | -118.5 | -134.8 | - | - | - | - |
| **Cov(d, $slp_m$)** | - | 11.6 | - | - | - | - |
| **Cov($slp_d$,m)** | | 11.7 | - | - | - | - |
| **Cov($slp_d$, $slp_m$)** | **-** | -3.7 | - | - | - | - |
| **Var(pe)** | 63.81 | 66.8 | 65.3 | 67.4 | - | 88.6 |
| **Var($slp_{pe}$)** | - | 0.13 | 0.14 | 0.2 | - | 0.03 |
| **Cov(pe, $slp_{pe}$)** | | **-2.9** | **-3.1** | **-3.6** | **-** | **-1.5** |
| **Var(e)** | 474.5 | 459.1 | 522.6 | 586.4 | 515 | 511.8 |
| **Var_Total** | 759.1 | 736.5 | 721.6 | 712.03 | 747.6 | 719.2 |

# Results:

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## Heritabilities (diagonal), genetic correlations and proportion of maternal permanent component relative to total phenotypic variance

| d | slp_d | m | slpm | d | slp_d | m | slpm |
|---|---|---|---|---|---|---|---|
| 0.34 | -0.523 | -0.74 | 0.641 | 0.16 | -0.488 | | |
| | 0.02 | 0.308 | -0.96 | | 0.01 | | |
| | | 0.17 | -0.258 | | | 0.05 | 0.998 |
| | | | 0.002 | | | | 0.0002 |
| | | pe | slp_pe | | | pe | slp_pe |
| | | 0.145 | -0.990 | | | 0.123 | -0.990 |
| | | | 0.0002 | | | | 0.0000 |

# Conclusions:

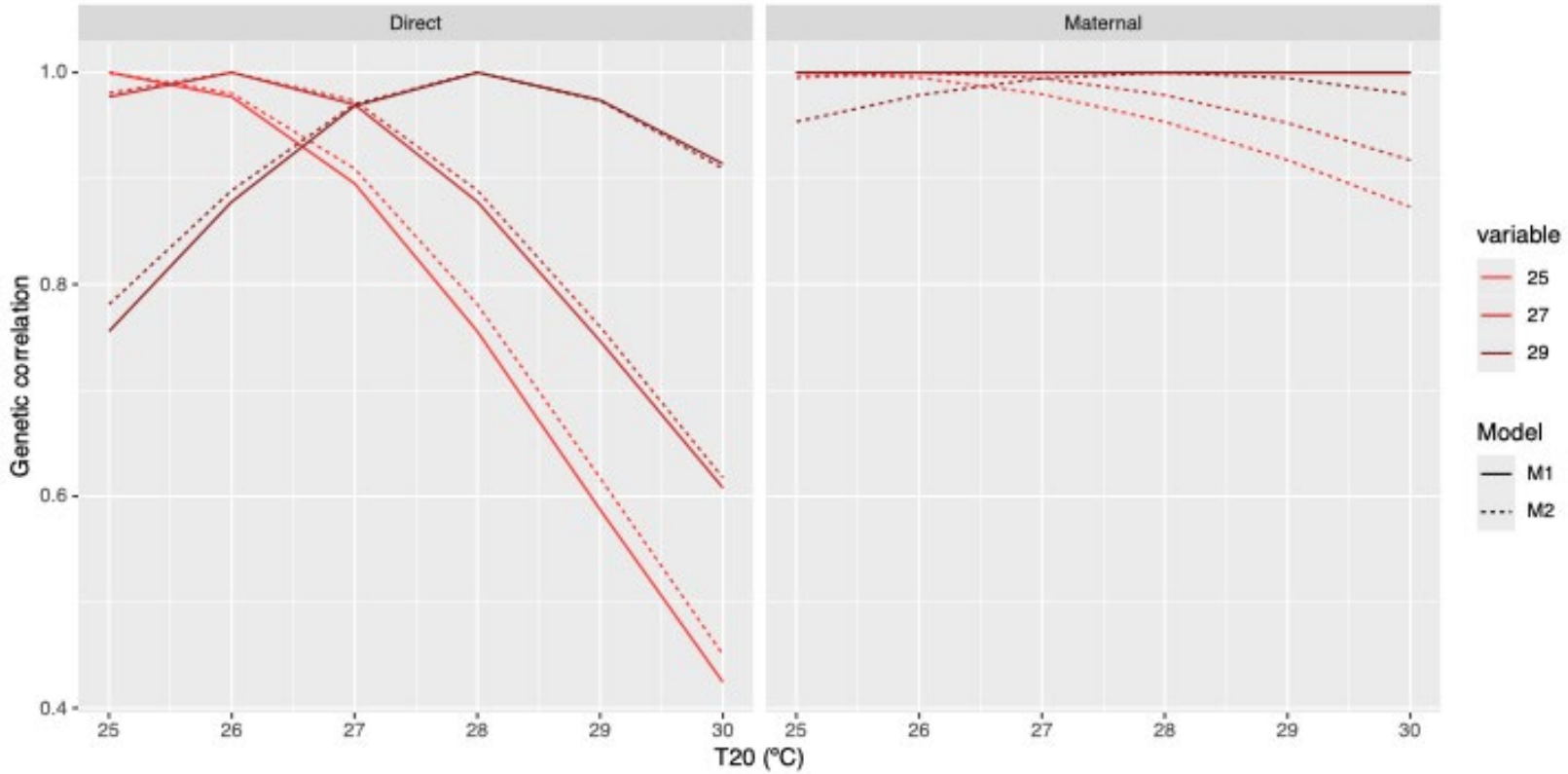
**1.- Up to now, the impact of HS does not seem to be very relevant in this breed. Differences in WWT and AFL represent 2-3% of the mean. Thermo-neutrality interval is very wide.**

**2.- Trades off between WWT production and heat tolerance seems to be model dependent.**

**3.- For the direct component we have estimated an antagonism between basal weight and thermotolerance.**

# Acknowledgements

This work has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement No 01059609 (Re-Livestock project)"


Direct
Maternal
1.0
0.8
0.6
0.4
Genetic correlation
25
26
27
28
29
30
T20 (°C)
variable
25
27
29
Model
M1
M2