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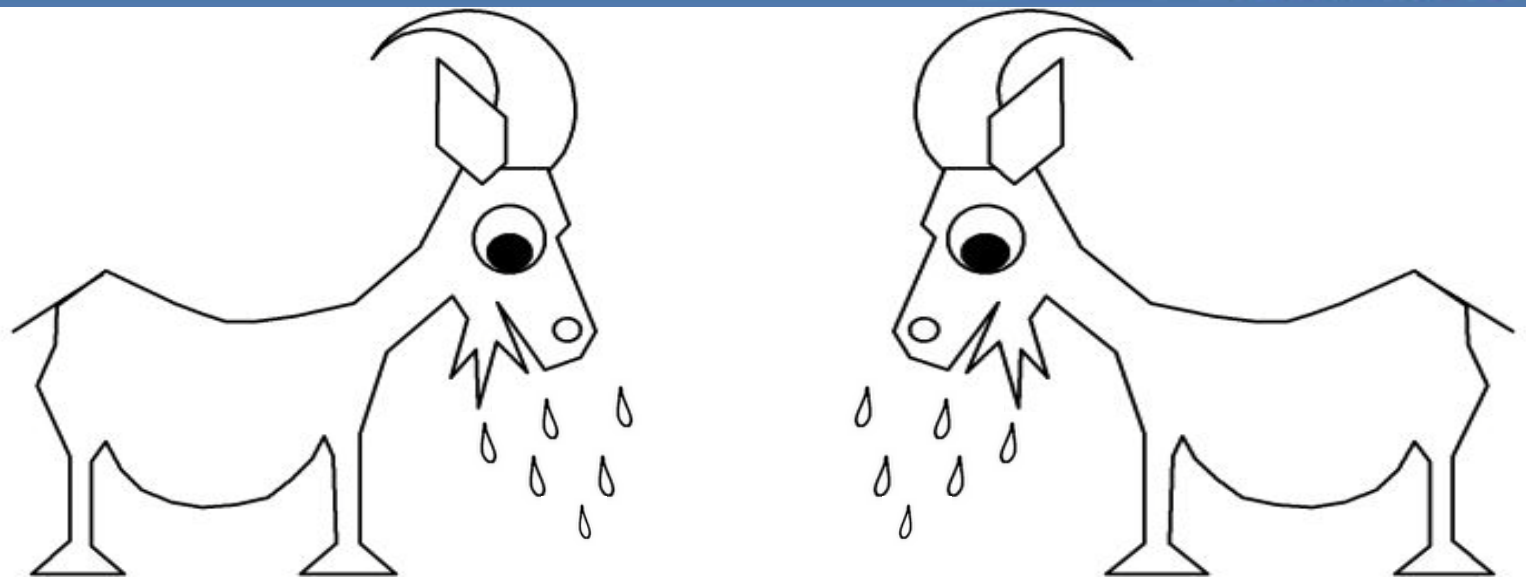

Physiological and nutritional changes to maintain milk yield in late lactating dairy goats exposed to extreme heat stress conditions

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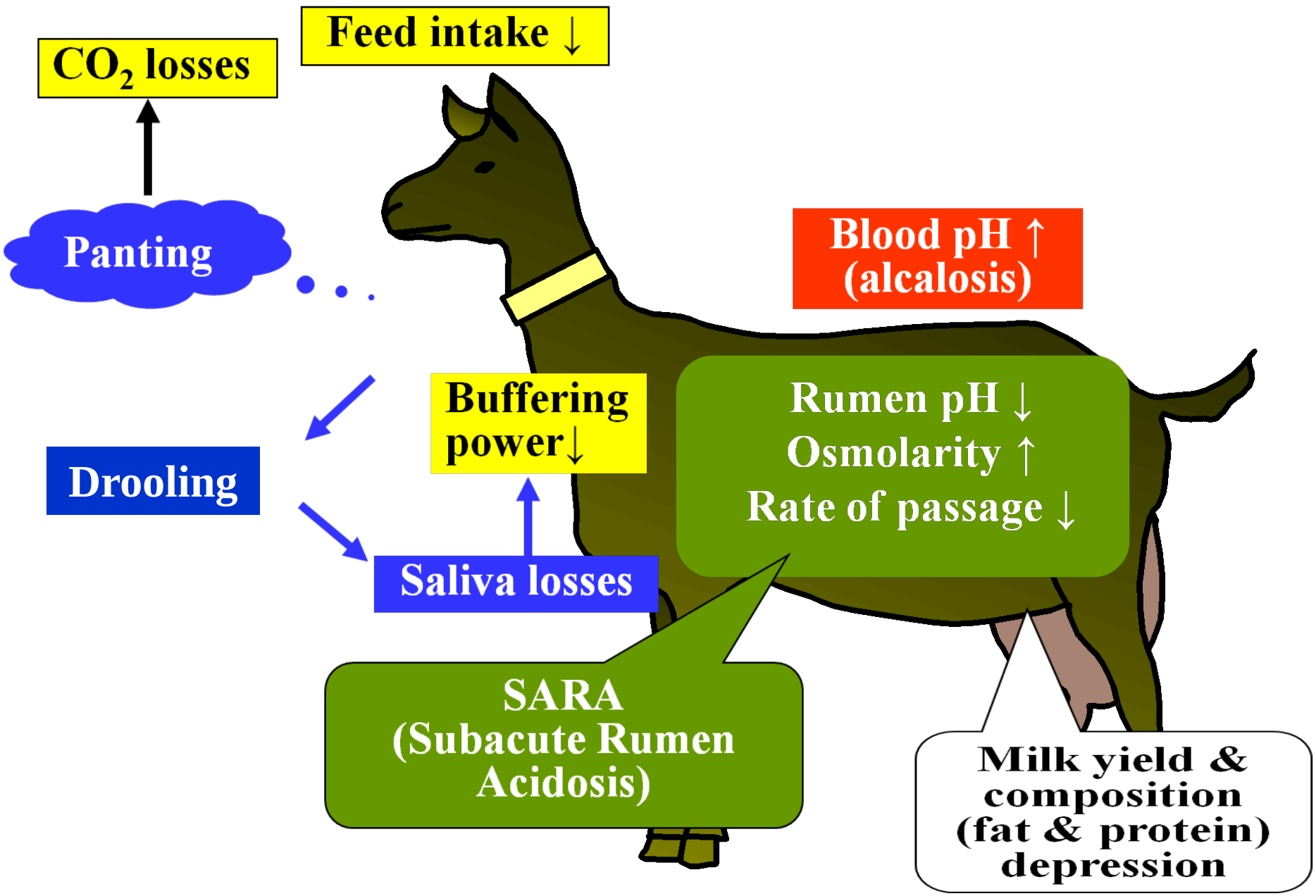
Introduction

- Goats perform well in arid zones.
- Goats are more tolerant to heat stress than dairy cows:
  - Lower BW : surface ratio.
  - Morphological adaptations (long ears, etc…).
  - Water conservation capacity and greater sweating rate.
- Few studies have been carried out on heat stress effects in <u>dairy</u> goats.

Introduction : Responses to HS

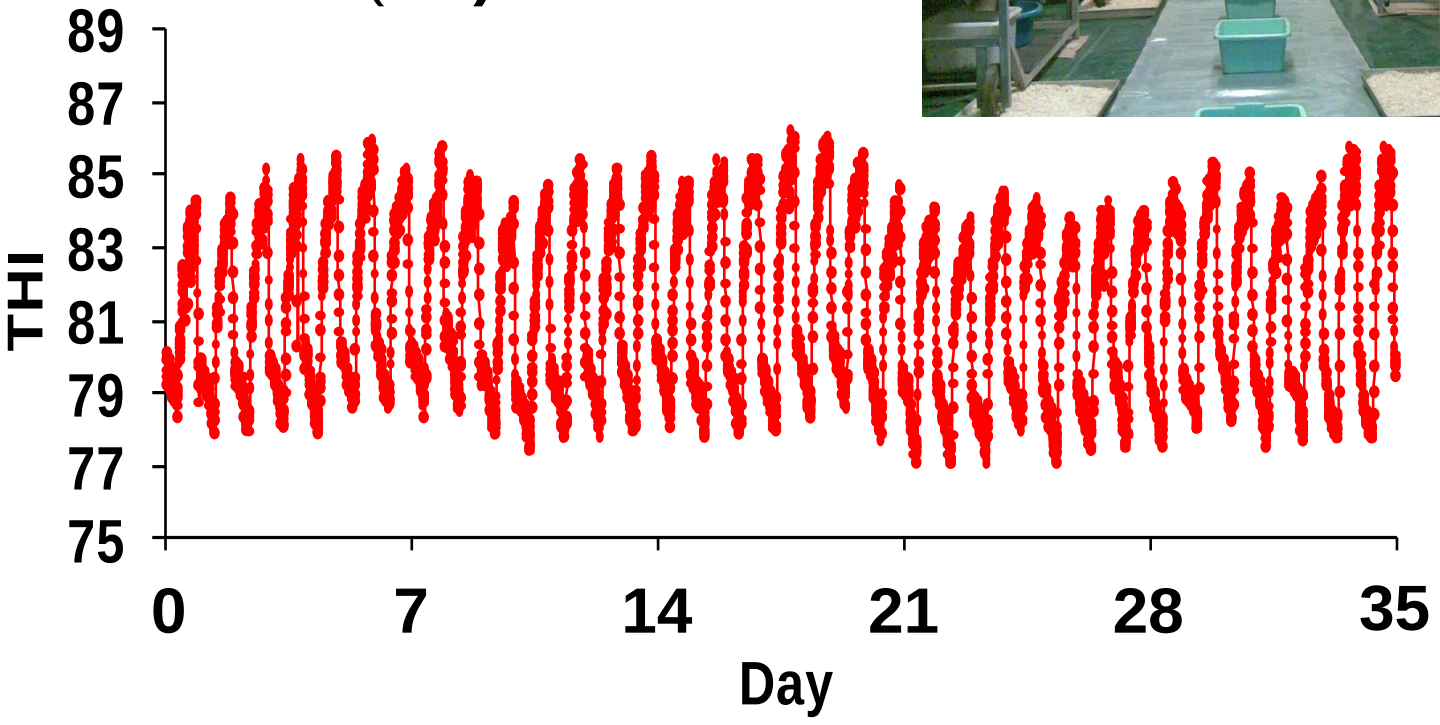


Objectives

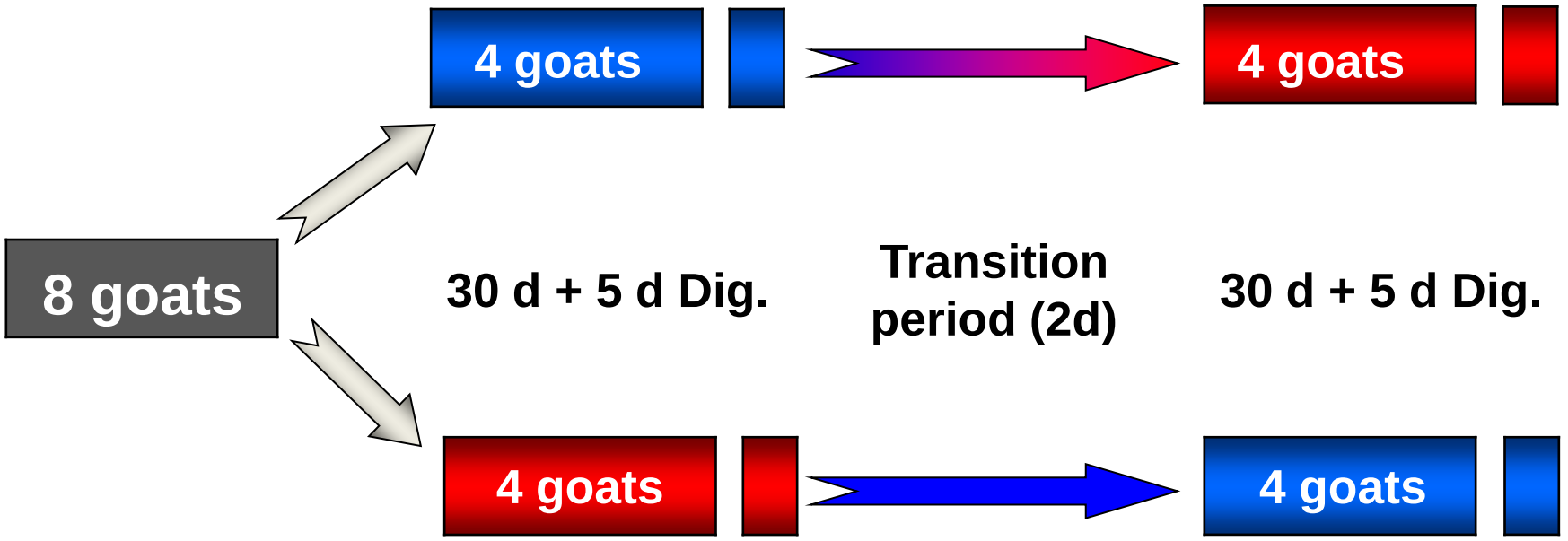
- **Evaluation of heat stress effects:**
  - **Nutritional: DMI, water balance, digestibility**
  - **Lactational: Milk yield & milk composition**
  - **Physiological: RT & RR**
  - **Metabolites: NEFA & blood ions**
  - **Acid-base indicators: pCO2, HCO_3, anion gap**
  - **Stress indicators: blood haptoglobin & fecal corticosterone**

Materials and Methods: Animals & treatments

- Eight multiparous Murciano-Granadina dairy goats in metabolic cages (**194 ± 3 DIM)**
- **Treatments: 2** conditions of temperature and relative humidity:
  - **Thermal neutral** (**TN**; **15** to **20°C** and **40 ± 5%; THI = 59** to **65**).
  - **Heat stress** (**HS**)



Materials and Methods: Experimental design



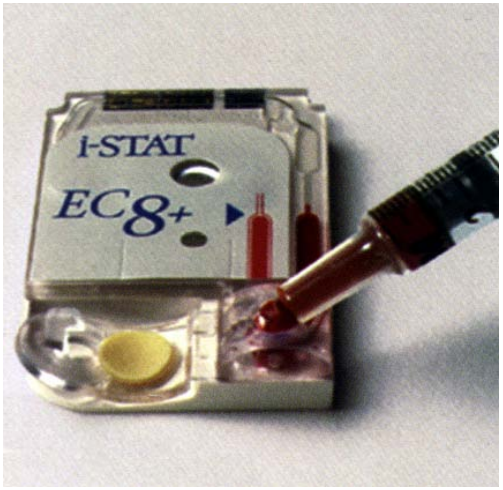
◂ 4 wk pre-exp. ▸ ⟵ 10 wk exp. ⟶

Materials and Methods: Measurements

- **Rectal temperatures** and **respiration rates** were **daily** recorded at **0800, 1200,** and **1700 h**.
- **DMI** and **water consumption (± 20g)** were daily recorded.
- **Milk yield** of individual goats was daily recorded.
- **Milk composition (TS, fat, protein, TP,** and **CN)** was evaluated **weekly** using **NIR** (Foss NIRSyestems 5000, Hillerod, Denmark).
- **Blood samples** were **weekly** taken for analyses of **NEFA** (Wako Chemicals, Neuss, Germany) and **haptoglobin** (Olympus AU400 analyzer, Hamburg, Germany).

Materials and Methods: Measurements

- **Metabolic & acid-base status**: at **d 25** (8 am & 17 pm) using an i-Stat analyzer (Abbott, IL). Glucose, urea, pH, Na, K, hemoglobin, hematocrit, CO_2 & HCO_3 concentrations.



- **Digestibility**: **DM, OM, CP, ADF,** and **NDF** (AOAC, 2003).
- **Urine pH**: samples at the last 2 d of each period.
- **Fecal corticosterone**: the last d of each period by RIA (RIA kit ICN Pharmaceutics, NY).

Materials and Methods: Statistical analyses

- **PROC MIXED** of **SAS** version **9.1.3** for repeated measurements
  - **Model**:

$$Y_{ijkl} = \mu + T_i + D_j + P_k + TD_{ij} + TP_{ik} + \varepsilon_{ijkl}$$

T_i = effect of treatment (i = 1 or 2)

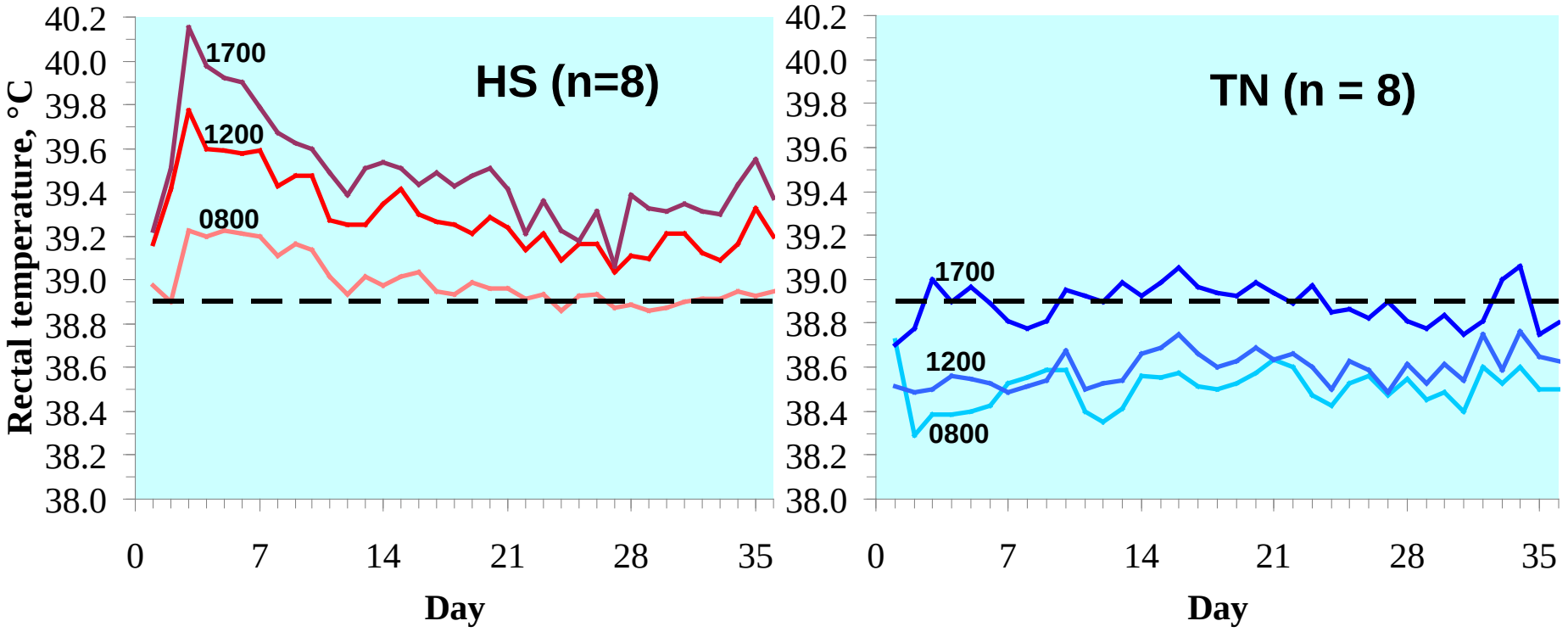
D_j = effect of the day (j = 1 to 35)

P_k = effect of period (k = 1 or 2)

- Data of digestibility, N balance, and fecal corticosterone were analyzed using **PROC GLM** of **SAS**.

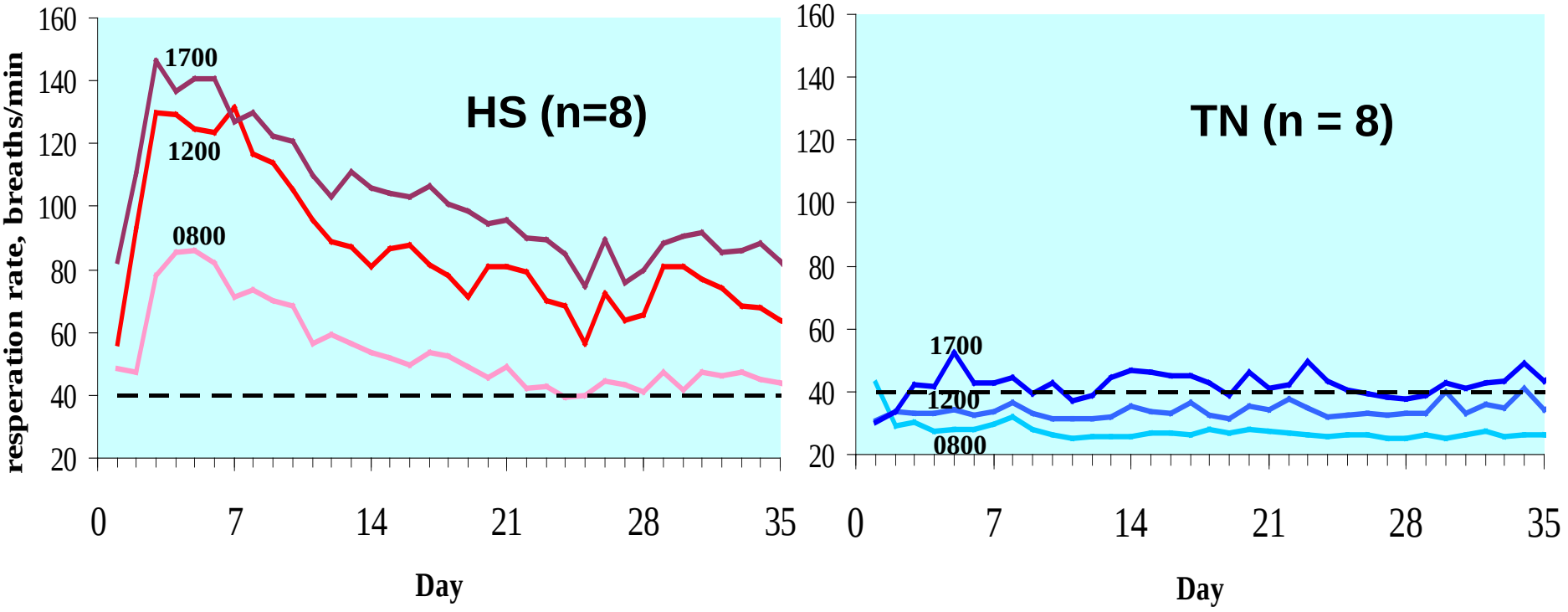
Results: Rectal temperature

Daily rectal temperatures at 8, 12, and 17 h in goats under heat stress (HS) or thermal neutral (TN) conditions



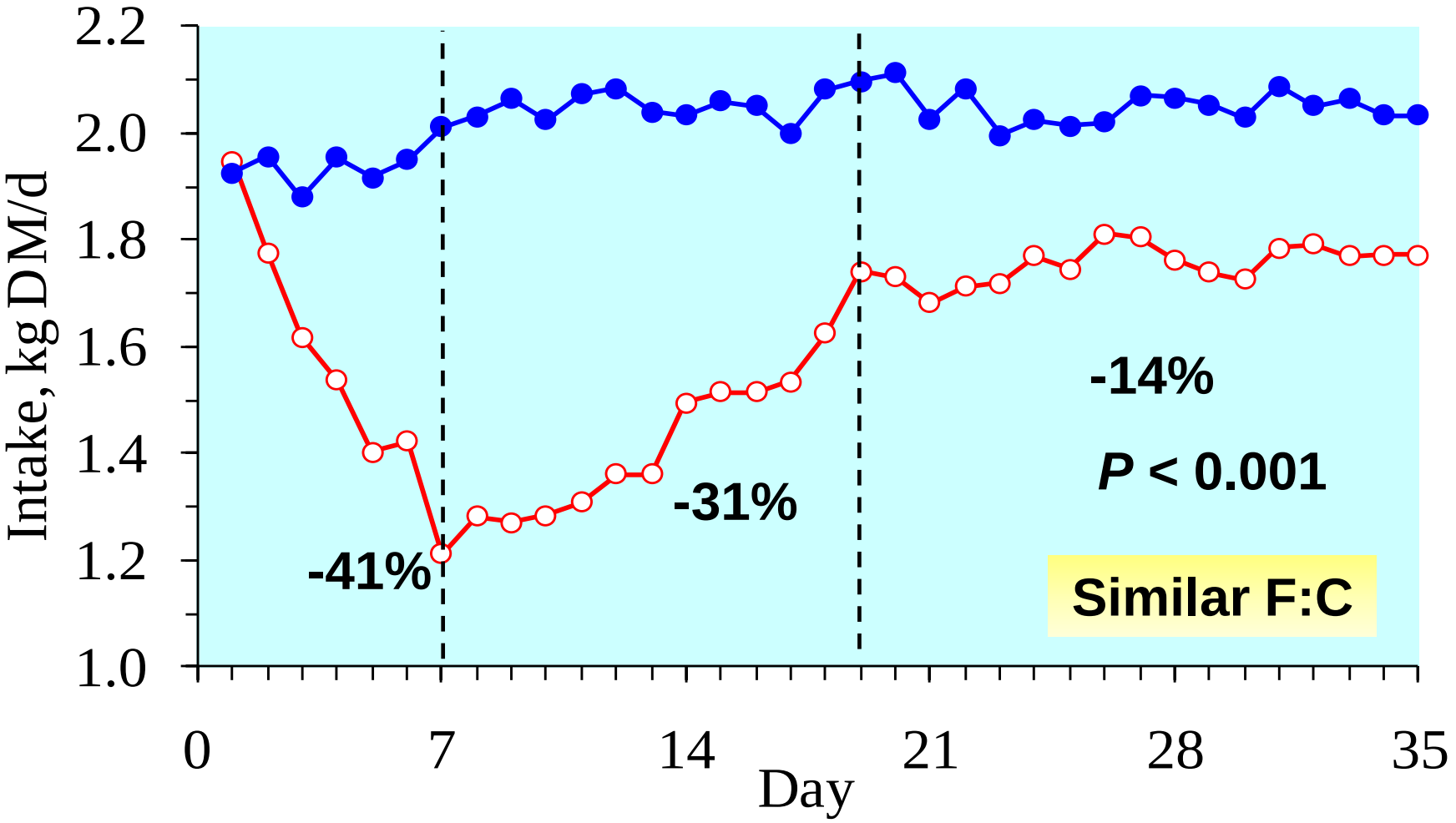
Results: Respiration rate

Daily respiration rate at 8, 12, and 17 h in goats under heat stress (HS) or thermal neutral (TN) conditions



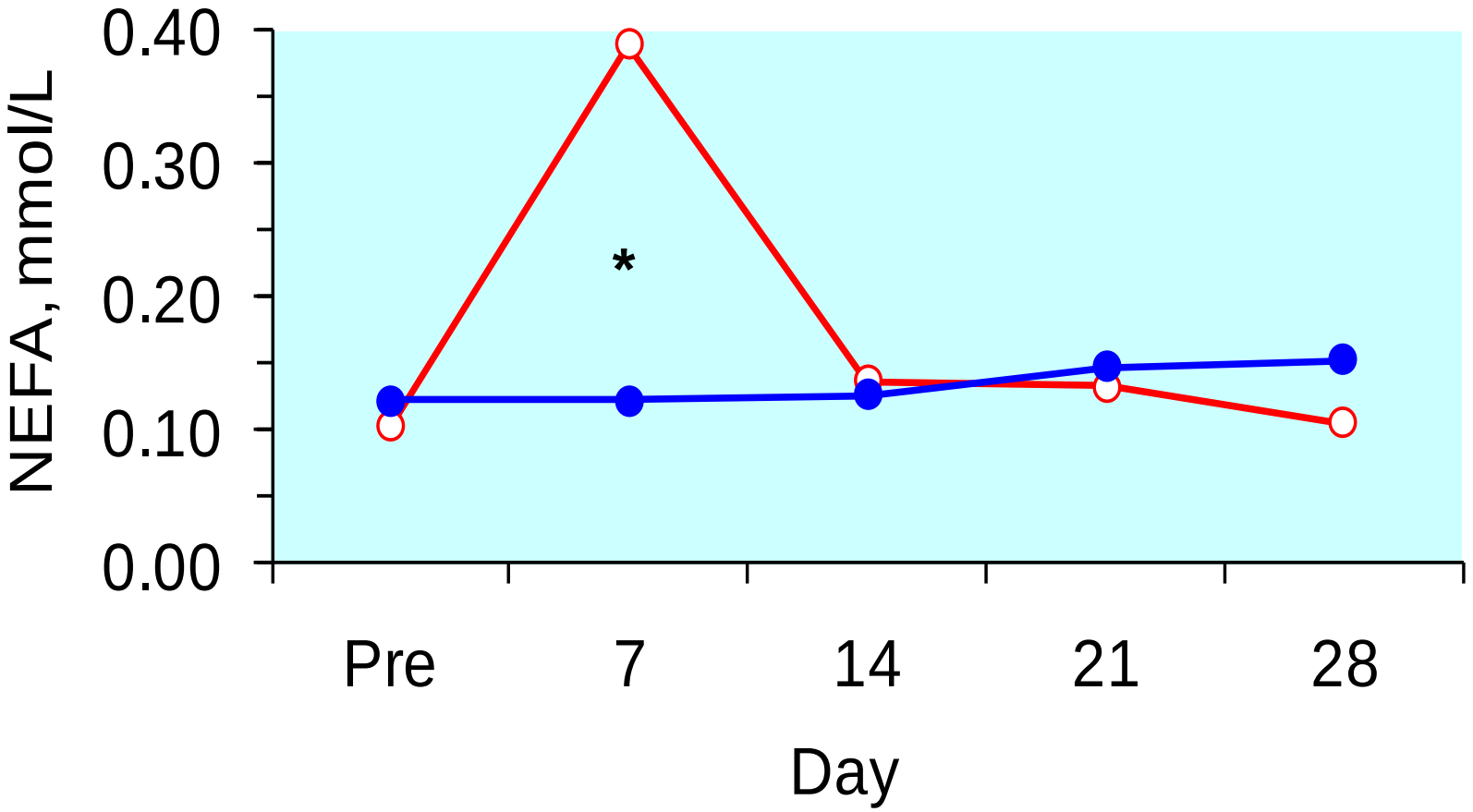
Results: Feed intake

Feed intake of dairy goats under thermal neutral (●; n = 8) or heat stress (○; n = 8) conditions



Results: Blood NEFA

NEFA in blood of dairy goats under thermal neutral (●; n = 8) or heat stress (○; n = 8) conditions



*** Indicates differences between TN and HS at each time point**

Results: Water balance

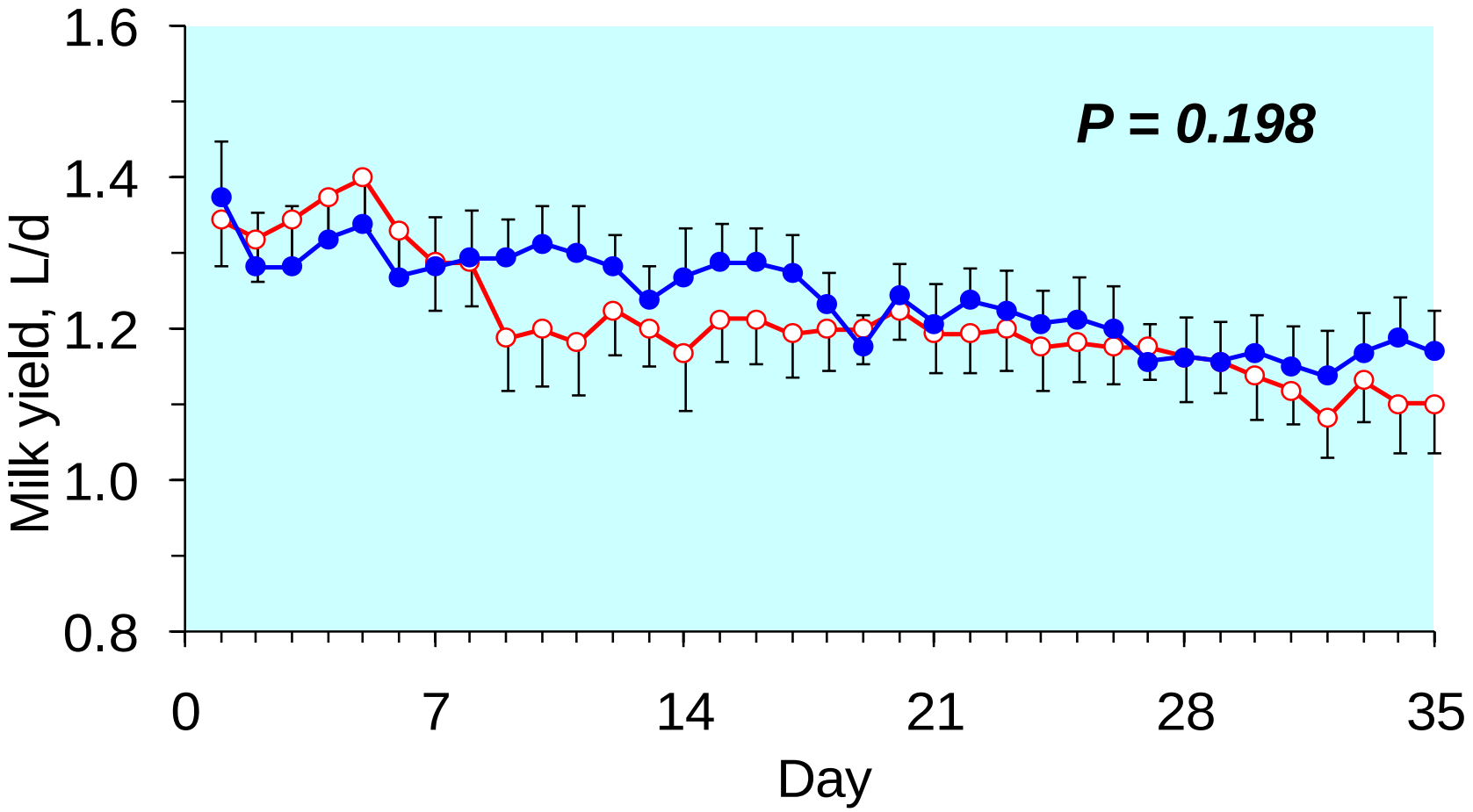
Water input and water losses in dairy goats under thermal neutral (TN) and heat stress (HS) conditions

Item	Treatment		SED	*P* <
	TN	HS		Treat.
Water intake, mL[1]	5,504	9,728	1,863	0.035
Water in food, mL	143	127	7	0.034
Water in milk, mL[1]	969	1,004	62	0.547
Urine volume, mL[1]	2,143	4,757	1,737	0.410
Water in feces, mL	1,426	825	144	0.002
Evaporation water, mL[1]	1,074	3,304	1,430	0.007

[1] Calculated by the difference between water input (water intake + water in food) and water losses in milk, urine, and feces without taking into account the water produced metabolically.

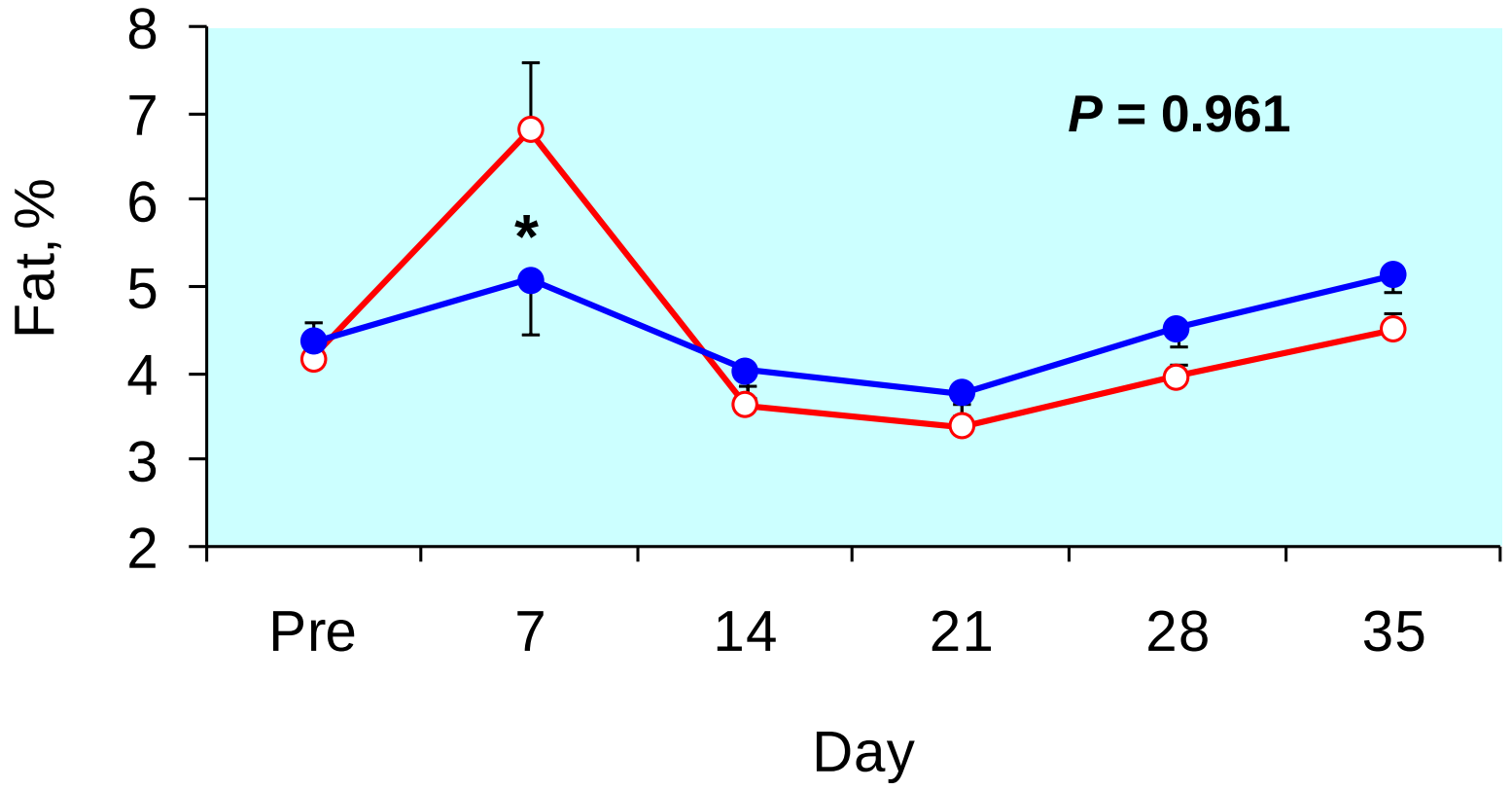
Results: Milk yield

Milk yield of dairy goats under thermal neutral (●; n = 8) or heat stress (○; n = 8) conditions



Results: Milk fat

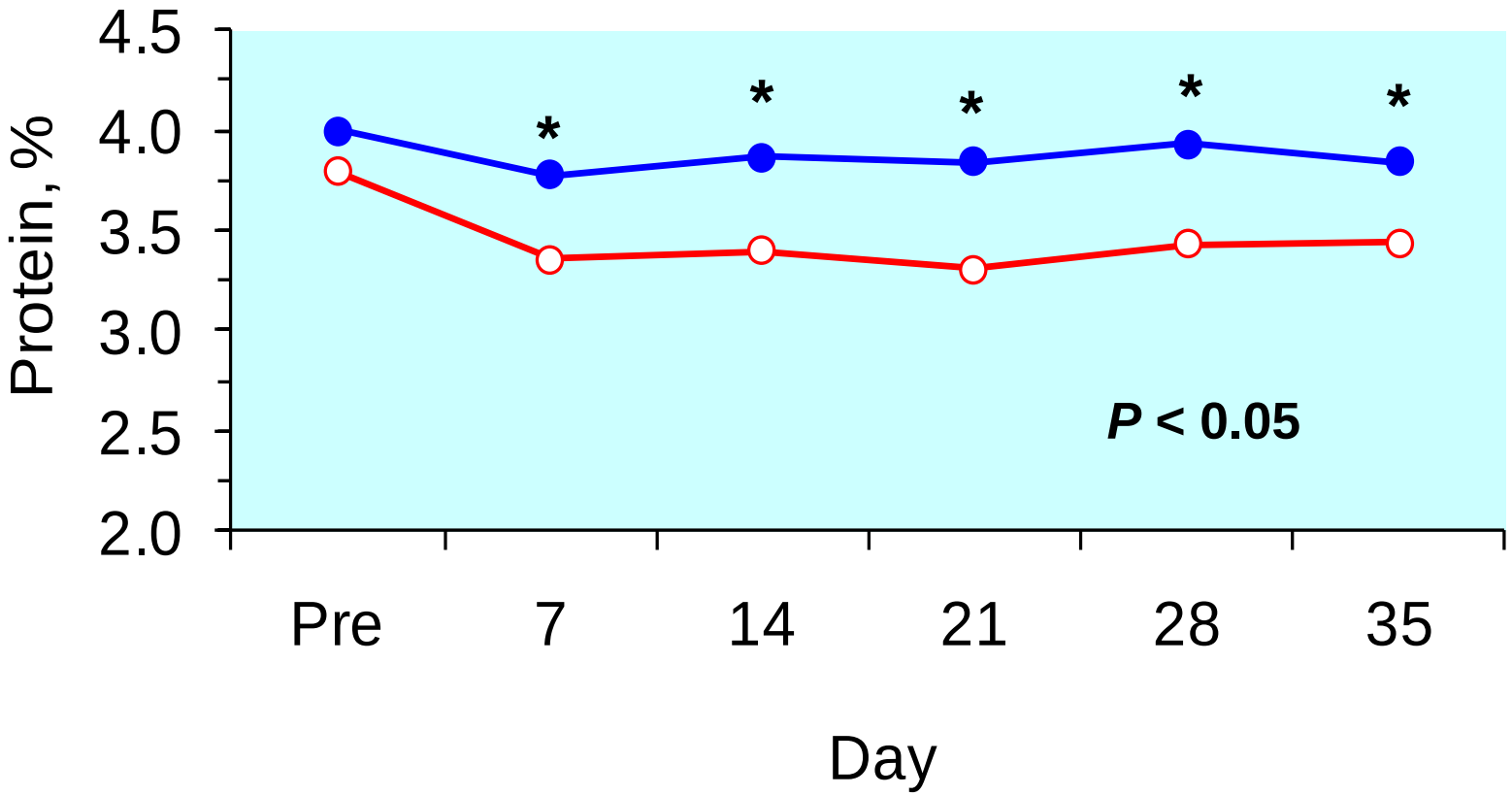
Milk fat of dairy goats under thermal neutral (●; n = 8) or heat stress (○; n = 8) conditions



*** Indicates differences between TN and HS at each time point**

Results: Milk protein

Milk protein of dairy goats under thermal neutral (●; n = 8) or heat stress (○; n = 8) conditions



*** Indicates differences between TN and HS at each time point**

Results: Digestibility

Digestibility coefficients of dairy goats under thermal neutral (TN) and heat stress (HS) conditions

Item	Treatment			*P* <
	TN	HS	SED	Treat.
Dry matter	56.6	58.8	2.3	0.121
Organic matter	58.8	61.2	1.4	0.109
Crude protein	70.5	72.1	1.5	0.306
Neutral detergent fiber	36.0	38.8	1.9	0.157
Acid detergent fiber	35.1	38.2	1.7	0.094

Results: N balance

Nitrogen balance of dairy goats under thermal neutral (TN) and heat stress (HS) conditions

Item	Treatment			*P* <
	TN	HS	SED	Treat.
Intake, g/d	48.4	42.1	0.8	0.001
Fecal excretion, g/d	14.3	11.8	0.8	0.010
Urinary excretion, g/d	20.3	16.4	1.3	0.012
Apparent absorption, %	70.5	72.1	1.5	0.306
Retention, g/d	13.9	13.9	1.0	0.950

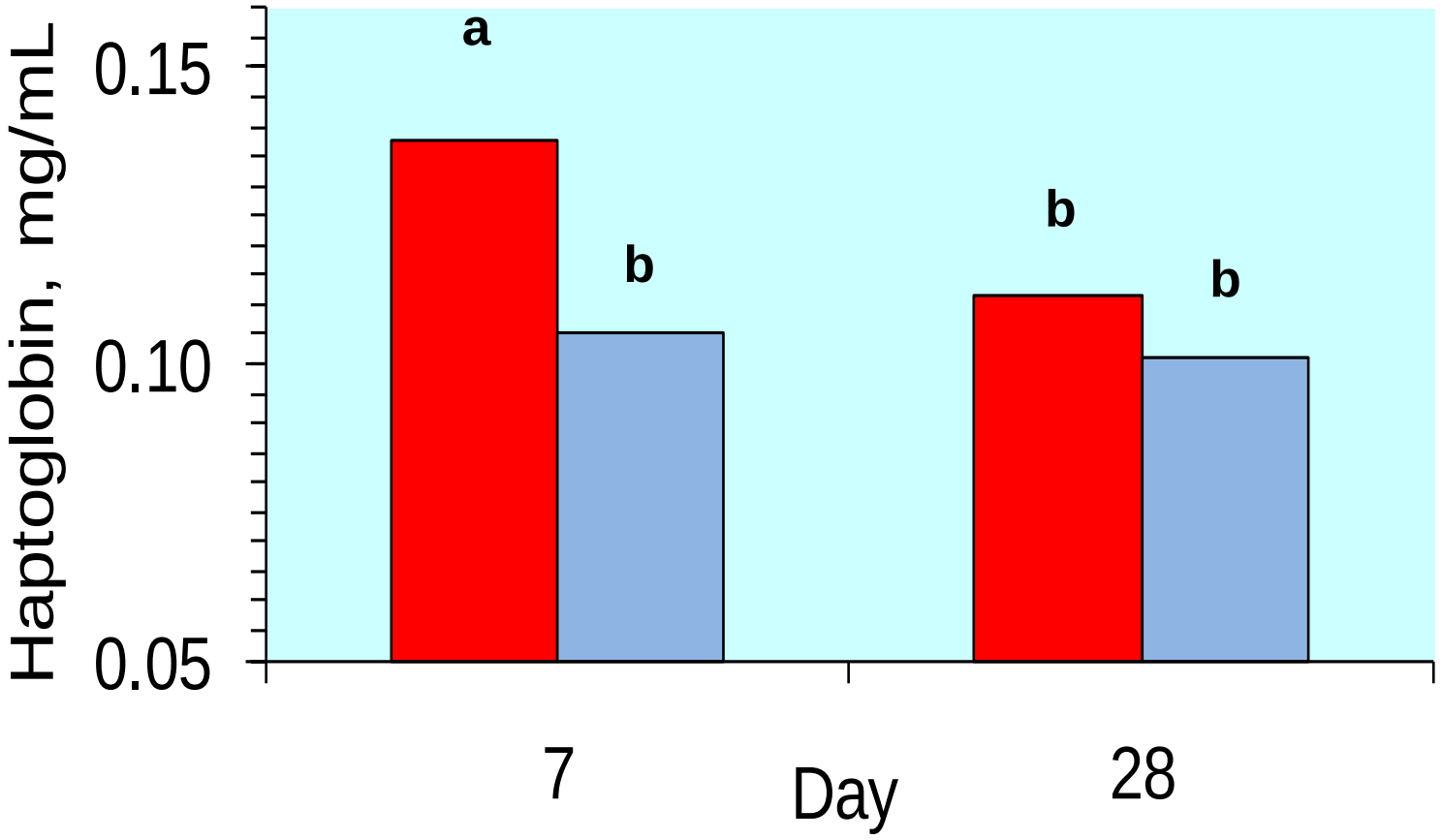
Results: Acid-base balance

AB indicators of dairy goats under thermal neutral (TN) and heat stress (HS) conditions

	TN		HS			*P* <
Item	0800 h	1700 h	0800 h	1700 h	SEM	Treat.
Na, mmol/L	140	140	142	141	1.2	0.161
K, mmol/L	3.8	4.2	3.7	4.3	0.1	0.793
Cl, mmol/L	105.0	108.9	108.3	110.4	0.9	0.031
pH	7.42	7.38	7.42	7.42	0.01	0.156
CO_2, mmol/L	26.9	24.4	22.3	21.5	0.8	0.002
Anion gap, mmol/L	12.50	12.00	16.50	14.00	0.73	0.001
pCO_2, mm Hg	38.9	39.8	33.1	31.5	1.7	0.006
HCO_3^-, mmol/L	25.71	23.41	21.29	20.51	0.83	0.003
Base excess	1.38	-1.75	-3.00	-4.00	0.87	0.005
Urine pH	9.09	8.94	8.91	8.85	0.08	0.108

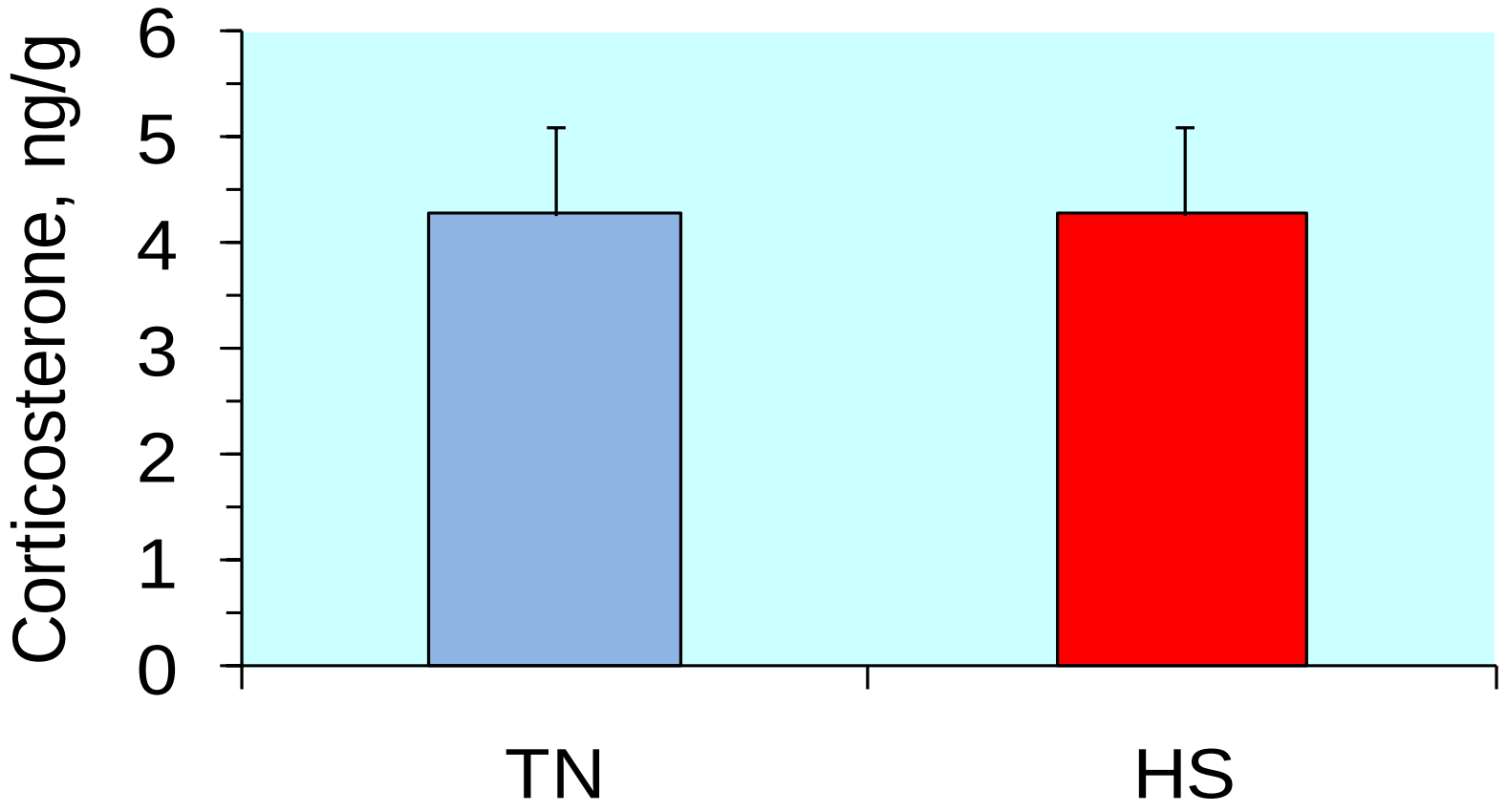
Results: Haptoglobin

Plasma haptoglobin of dairy goats under thermal neutral (■; n = 8) or heat stress (■; n = 8) conditions



Results: Fecal corticosterone

Fecal corticosterone at d 35 of dairy goats under thermal (■; n = 8) or heat stress (■; n = 8) conditions



Conclusions: HS vs. TN dairy goats (1/2)

Heat-stressed dairy goats:

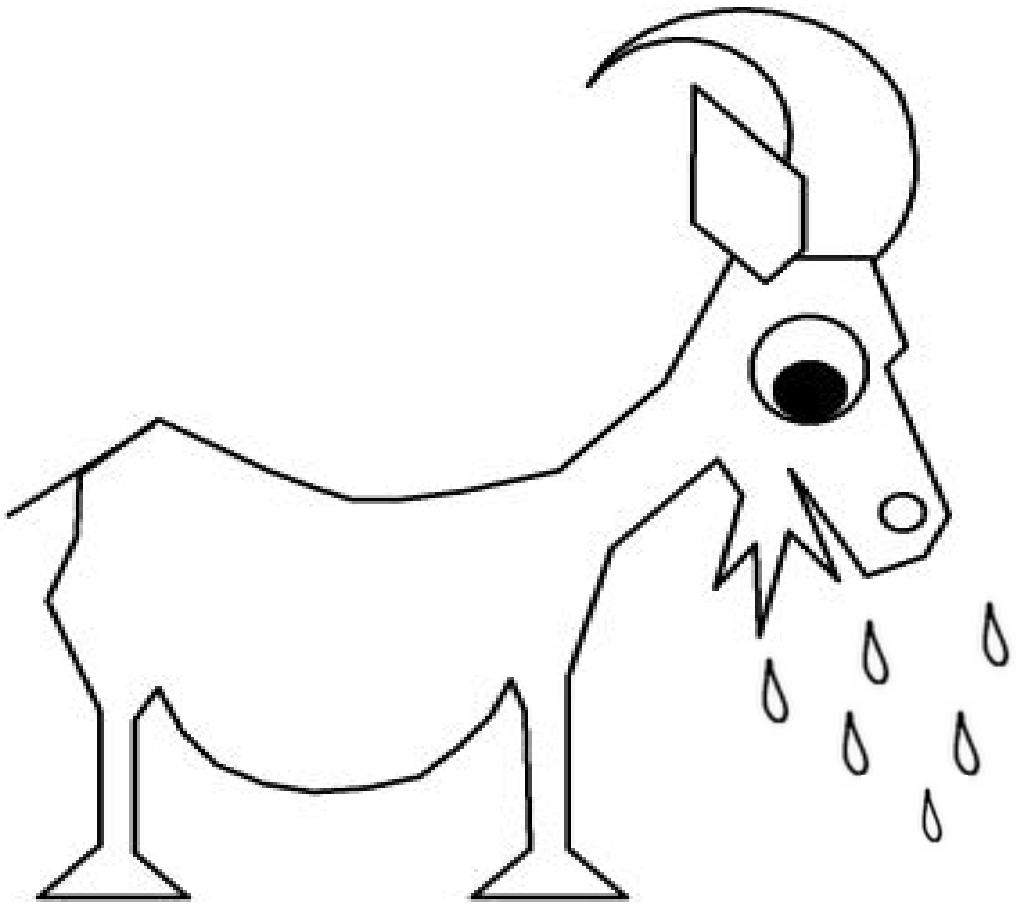
- **Partially adapted to HS conditions after wk 3.**
- **Had lower DMI, but similar milk yield to TN when fed with the same F:C ratio.**
- **Mobilized body reserves (increased NEFA) in wk 1 to maintain milk yield under minimal DMI.**
- **Had lower milk protein, but similar milk fat.**
- **Maintained blood pH within the normal range by decreasing [HCO_3^-] and increasing [Cl^-].**
- **Had graetr blood haptoglobin at d 7 which decreased thereafter when goats adapted to HS.**

Conclusions: HS vs. TN dairy goats (2/2)

- Had similar fecal corticosterone to TN at d 35, indicating that it did not reflect chronic HS.
- Tended to increase digestibility (2 to 3 points), which may partially compensate for DMI decrease.
- Retained similar N to TN goats, but ingested N might have been directed to another functions rather than milk protein synthesis.

Further studies are needed to:

- Test the HS effects in early lactation.
- Clarify whether reduced milk protein content is related to a nutrient limiting factor or reduced mammary protein synthesis…



Thanks for the attention