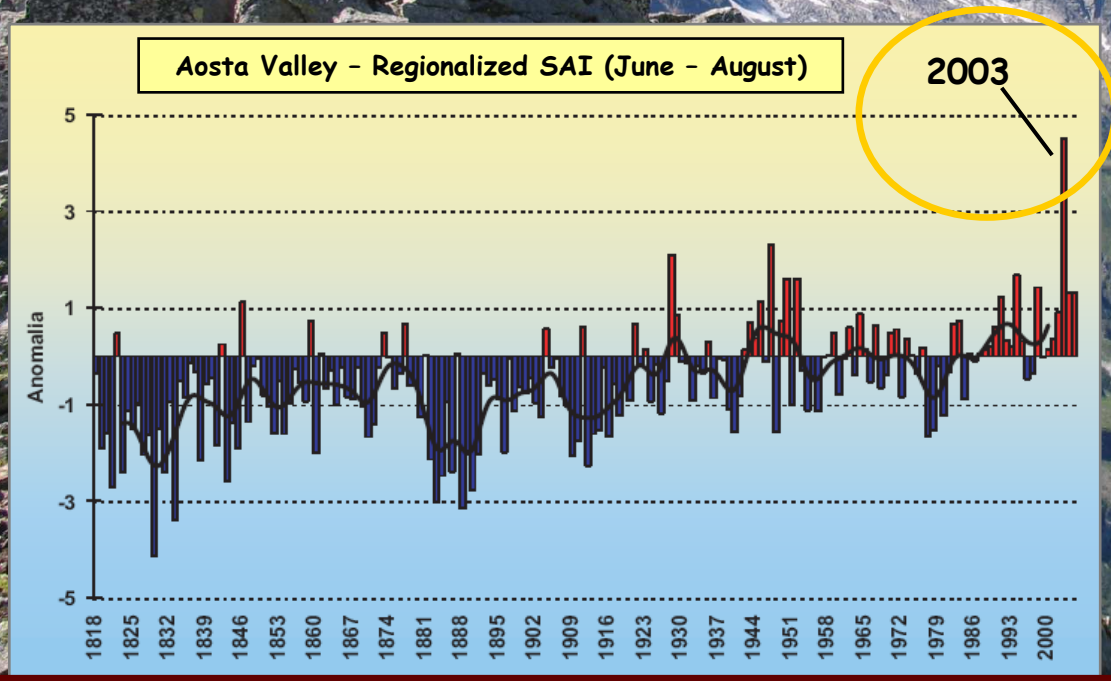
Effect of exposure to heat stress conditions on milk yield and quality of Aosta dairy cows grazing on Alpine pasture

INTRODUCTION

Temperatures increase in the Alpine regions

- Since the end of the 19th century, marked temperatures raise in the Alps (Böhm *et al.*, 2001; Brunetti *et al.*, 2006)
- +1°C in NW Italy in the years 1952-2002 (Hardenberg *et al.*, 2007)
- years 2002-2005: atypical climatic events (Regione Autonoma Valle d'Aosta, 2006)
- year 2003: the hottest summer in the last half millenium (Luterbacher *et al.*, 2004)



Exceptional anomaly in summer 2003 in Aosta Valley (Regione Autonoma Valle d'Aosta, 2006).

INTRODUCTION

Negative effects of heat stress conditions

COWS

- Thermo-regulation (Nardone *et al.*, 2006)
- Worsening of the animal welfare (Brouček *et al.*, 2006)

GRASS

- Intense lignification (Van Soest, 1994)
- Increase in metabolic activities (Van Soest, 1994)

- Lower digestibility
- Decrease in voluntary ingestion

1) REDUCTION OF MILK YIELD
2) CHANGES IN MILK QUALITY

AIMS OF THE STUDY

Lack of knowledge on the effects of heat stress conditions on milk yield and quality while grazing

1.

❖ Examine how much, at pasture, heat stress can influence:

a. milk yield

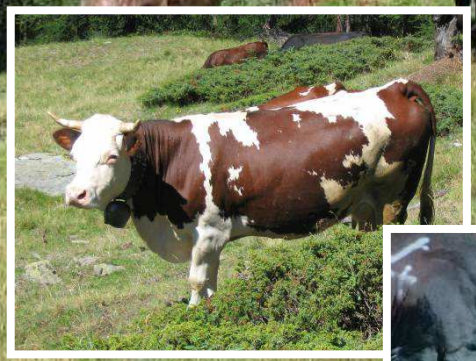
b. milk fat and protein contents

c. milk somatic cell count

d. milk fatty acid composition

2.

❖ Deepen if differences among cattle breeds exist in response to variation of the climatic settings



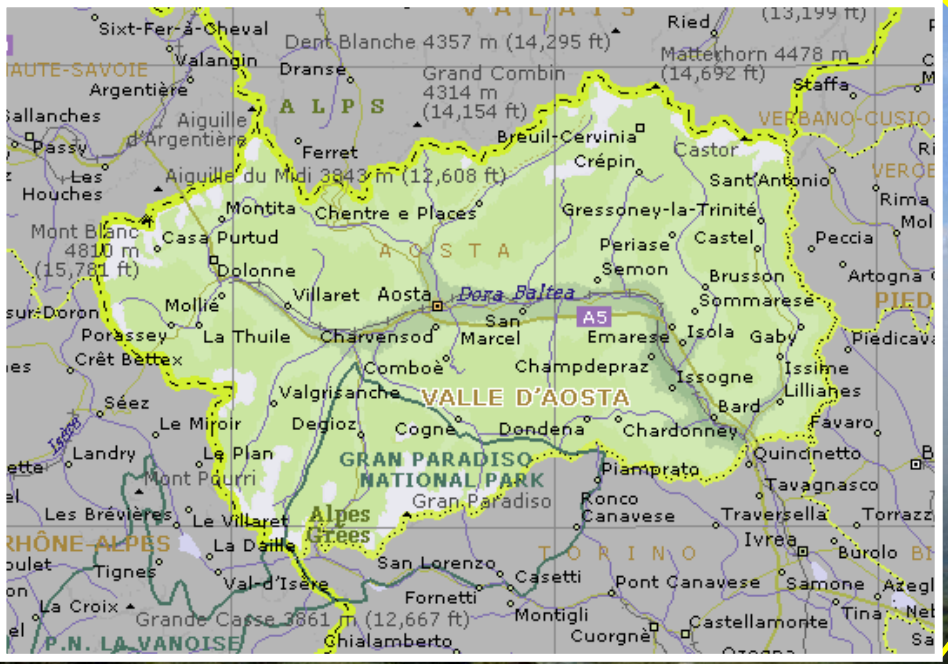
MATERIALS AND METHODS

Animals, feed and management

- Two-years research (2003 and 2004)
- 28 dairy cows (14 Aosta Red Pied and 14 Aosta Black Pied-Chestnut)
- Three-months grazing season
- *Ad libitum* fresh grass + concentrate (1kg)

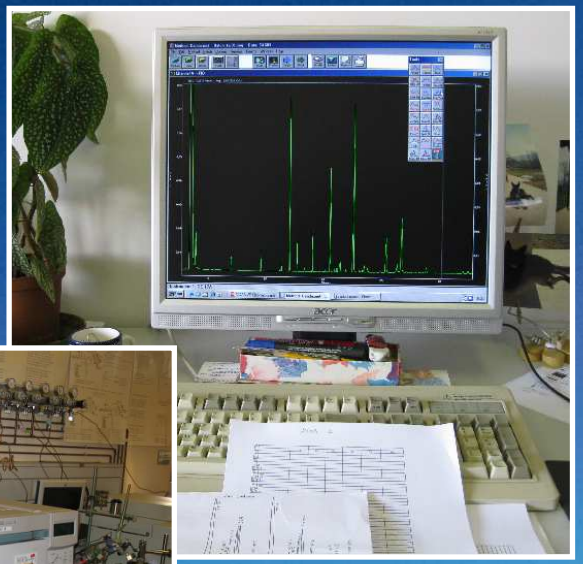
Aosta Red Pied

Aosta Black Pied – Chestnut (vulnerable breed)



Aosta Valley

MATERIALS AND METHODS



Sample collection and analysis

- Monthly milk samples collection
- Grass samples collected twice a week

- Chemical analysis of milk:

1. fat and protein (infrared spectroscopy)
2. SCC (automatic cell counter)
3. fatty acid composition (GC)

- Chemical analysis of fresh grass:

1. DM, CP, EE, ash, NDF (AOAC, 2000)
2. fatty acid composition (GC)

Meteorological data

- Data recorded at one-hour interval at the nearest meteorological station:

1. air temperature
2. relative humidity

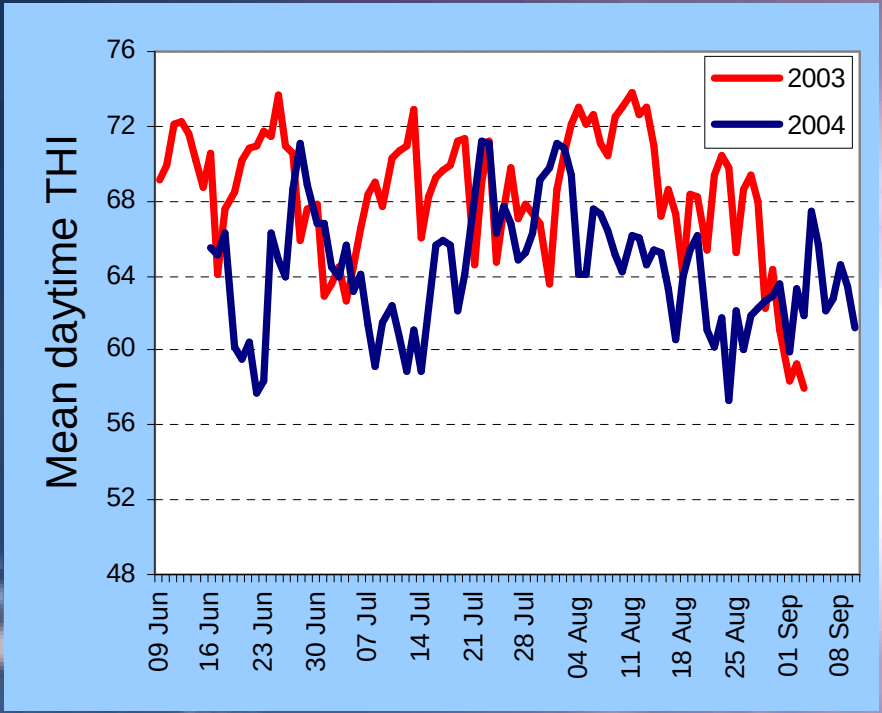
THI was calculated (Ravagnolo et al., 2000)

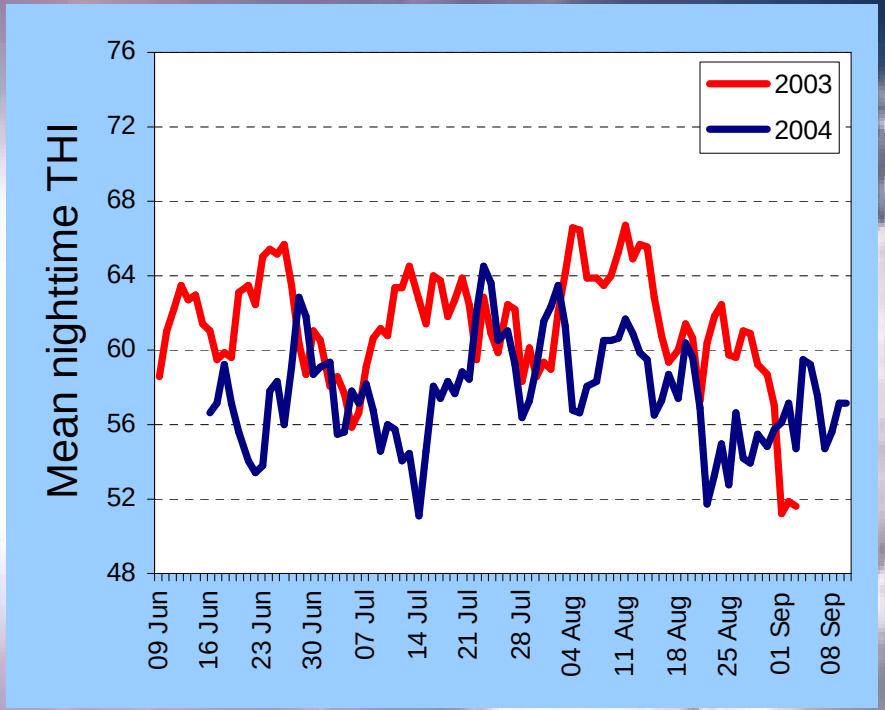
Statistical analysis

- ABP and AC: single statistic group
- Data submitted to Analysis of Variance (GLM procedure of SPSS)
- Significance declared at $P<0.05$

RESULTS AND DISCUSSION

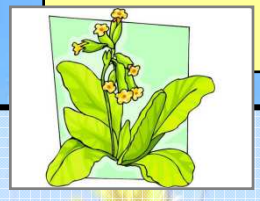
Temperature-Humidity Index





	YEAR 2003	YEAR 2004
THI (0-24h)	65.2 ± 3.2 (mean ± SD)	61.2 ± 3.0 (mean ± SD)
THI exceeding 68	73/87 days (30.6% of total time)	39/87 days (9.5% of total time)
THI exceeding 72	50/87 days (11.9% of total time)	9/87 days (1.9% of total time)

RESULTS AND DISCUSSION



Chemical composition of forages[1]

	YEAR 2003 n=22	YEAR 2004 n=23	P
Dry Matter (%)	39.10 ± 11.41	34.48 ± 2.06	ns
Crude Protein (%DM)	10.73 ± 4.68	14.65 ± 4.12	**
NDF (%DM)	54.71 ± 7.98	49.17 ± 7.03	*
C16:0 (%TFA)	27.66 ± 4.67	19.64 ± 2.08	***
C18:2 n6 (%TFA)	18.78 ± 5.25	21.16 ± 2.98	ns
C18:3 n3 (%TFA)	30.71 ± 8.49	42.30 ± 4.95	***
Total SFA (%TFA)	39.08 ± 6.96	28.79 ± 3.17	***
Total MUFA (%TFA)	11.43 ± 3.41	7.75 ± 1.50	***
Total PUFA (%TFA)	49.49 ± 8.54	63.46 ± 3.45	***

[1]Values are expressed as mean ± standard deviation of the mean.
TFA = total fatty acids; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.
Significance: ***P<0.001; ** P<0.01; * P<0.05; ns: not significant.

RESULTS AND DISCUSSION

Milk yield, milk components and somatic cell count[1]

	AOSTA RED PIED		P	AOSTA BLACK PIED - CHESTNUT		P
	Year 2003 n=42	Year 2004 n=42		Year 2003 n=42	Year 2004 n=42	
Milk yield ($kg*h^{-1}*d^{-1}$)	10.29 ± 4.39 ^{A}	11.14 ± 3.64 ^{A}	**	7.83 ± 3.06 ^{B}	7.28 ± 2.15 ^{B}	ns
DMI[2] ($kg*h^{-1}*d^{-1}$)	13.73 ± 1.23 ^{A}	14.22 ± 1.28 ^{A}	**	12.95 ± 0.85 ^{B}	12.79 ± 0.80 ^{B}	ns
Fat yield ($kg*h^{-1}*d^{-1}$)	0.38 ± 0.14 ^{A}	0.42 ± 0.14 ^{A}	**	0.30 ± 0.12 ^{B}	0.27 ± 0.10 ^{B}	ns
Protein yield ($kg*h^{-1}*d$)	0.33 ± 0.13 ^{A}	0.38 ± 0.11 ^{A}	**	0.27 ± 0.09 ^{B}	0.26 ± 0.07 ^{B}	ns
SCC (no. 1000 ml^{-1})	215.06 ± 80.76	190.07 ± 104.79	ns	179.51 ± 76.75	263.27 ± 104.40	ns

[1]Values are expressed as mean ± standard deviation of the mean.
[2]Estimated according to NRC (2001).
DMI = dry matter intake; SCC = somatic cell count.
Asterisks within rows indicate statistically significant difference between years (** P<0.01; ns: not significant).
Different letters within rows indicate, in the same year, statistically significant difference between breeds (A,B: P<0.001).

RESULTS AND DISCUSSION

Milk fatty acid composition - %TFA - (1)[1]

	AOSTA RED PIED		P	AOSTA BLACK PIED - CHESTNUT		P
	Year 2003 n=42	Year 2004 n=42		Year 2003 n=42	Year 2004 n=42	
SMCFA	43.25 ± 3.29	47.24 ± 4.04 ^{a}	***	41.84 ± 3.71	45.00 ± 3.48 ^{b}	**
LCFA	56.76 ± 3.29	52.77 ± 4.03 ^{b}	***	58.17 ± 3.72	55.00 ± 3.48 ^{a}	**
Total SFA	55.08 ± 2.85	59.83 ± 3.23 ^{a}	***	53.68 ± 3.90	57.46 ± 3.64 ^{b}	***
Total MUFA	39.29 ± 2.94	35.16 ± 2.95 ^{b}	***	40.30 ± 3.79	37.13 ± 3.13 ^{a}	***
Total PUFA	5.63 ± 0.73 ^{b}	5.01 ± 0.70 ^{ß}	***	6.03 ± 0.80 ^{a}	5.42 ± 0.84 ^{a}	**
HSFA	37.99 ± 3.05 ^{a}	41.92 ± 3.85 ^{a}	***	36.50 ± 3.22 ^{ß}	40.03 ± 3.19 ^{ß}	***
SFA/UFA	1.23 ± 0.14	1.51 ± 0.20 ^{a}	***	1.17 ± 0.18	1.37 ± 0.20 ^{b}	***

[1]Values are expressed as mean ± standard deviation of the mean.
SMCFA = short and medium chain fatty acids (C10-C16:1); LCFA = long chain fatty acids (C17-C18:3); HSFA = hypercholesterolemic saturated fatty acids (sum of C12:0+C14:0+C16:0); SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.
Asterisks within rows indicate statistically significant difference between years (***P<0.001; ** P<0.01; * P<0.05; ns: not significant).
Different letters within rows indicate, in the same year, statistically significant difference between breeds (A,B: P<0.001; a,b: P<0.01; a,ß: P<0.05).

CONCLUSIONS

Milk production, fat and protein contents

Under heat stress conditions significative reduction in milk yield, fat and protein yields, but only in Aosta Red Pied cows

Milk fatty acid composition

Significant improvement both in Aosta Red Pied and Aosta Black Pied-Chestnut:

1. decrease in hypercholesterolaemic fatty acids
2. increase in mono- and polyunsaturated fatty acids, positively correlated with human health

Differences between cattle breeds

Aosta Black Pied-Chestnut cows demonstrated higher degree of heat tolerance and showed a better milk fatty acid composition than Aosta Red Pied ones

Under unfavourable climatic conditions genetic differences among breeds are less pronounced

CONCLUSIONS

Climatologists agree on a more frequent recurrence, in the future, of exceptional heat waves similar to the one that occurred in summer 2003 (Beniston and Diaz, 2004; Meehl and Tebaldi, 2004; Schar *et al.*, 2004)

SIGNIFICANT ECONOMIC LOSSES

- Quantification of the levels of variation in milk yield and quality of different ruminant species and breeds
- Safeguard autochthonous breeds that are able to tolerate hard climatic events