Sicurezza Alimentare: Confronto aperto sull'attualità e sul futuro della professione veterinaria

Cambiamenti climatici e produzioni agricole e zootecniche

Umberto Bernabucci

bernab@unitus.it

UNIVERSITÀ DEGLI STUDI DELLA Tuscia

Dafne
Dipartimento di scienze e tecnologie per l'Agricoltura, le Foreste, la Natura e l'Energia

Fiuggi
7-8.11.2019

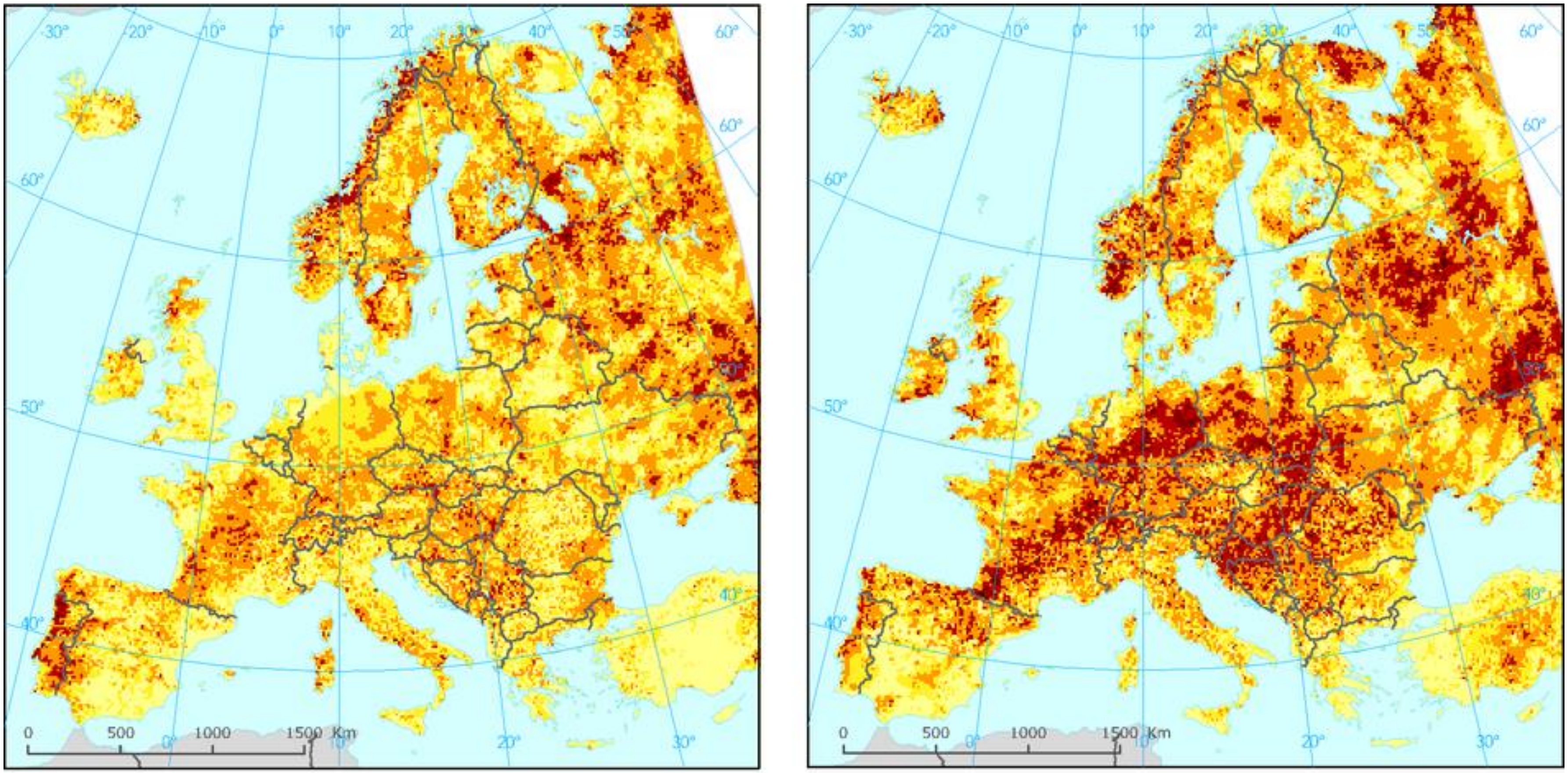
Outline

1. General aspect of climate change
2. THI
3. Heat Stress
4. Metabolic acclimation to heat stress:
5. Immunity and health
6. Reproduction
7. Milk production
8. Concluding remarks

1. General aspects of climate changes

Heat waves frequency in Europe

1961-1990 **2071-2100**



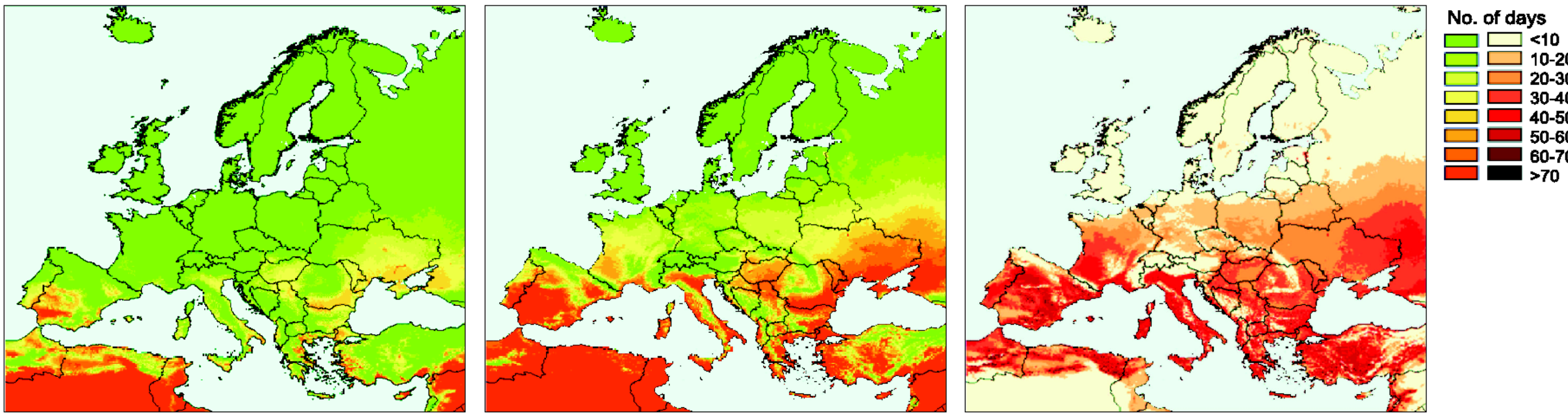
Heat wave frequency for the periods 1961–1990 (left) and 2071–2100 (right)
Based on the IPCC-SRES A2 emission scenario and the DMI climate model

< 1 | 1 | 2–3 | 4–5 | 6–7 | 8–9 | ≥ 10 | Outside report coverage

European Environment Agency

Increase in days of tropical nights

1961-1990 2071-2100 **+30-40%**



Tropical Nights, average 1961-1990 for June, July and August

Tropical Nights, average 2071-2100 for June, July and August

Change in Days of Tropical Nights from Control To Scenario Period, for June, July and August

Increrase of the night-time temperature

European Environment Agency

2. THI

Bioclimatic index

Other than only temperature to estimate heat stress in farm animals a specific thermal index is adopted.

The THI (temperature-humidity index) is the index most used and is a combination between temperature and humidity effect.

Kibler (1964), Johnson (1980):

$THI = T_{db} + 0.36T_{dp} + 41.2° \ C$

Kelly and Bond (1971):

$THI = (1.8 * T_{db} + 32) - (0.55 - 0.55 * RH/100) * [(1.8 * T_{db} + 32) - 58)]$

Tdb = dry bulb temperature (° C)

Tdp = dew-point temperature (° C)

Weather Safety Index (THI) chart

Relative Humidity

Temperature, °C	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
21	64	64	64	65	65	65	66	66	66	67	67	67	68	68	68	69	69	69	70	70
22	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
23	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
24	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
26	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
27	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
28	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
29	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
30	71	72	73	74	74	75	[illegible]	[illegible]	[illegible]	[illegible]	79	80	81	81	82	83	84	84	85	86
31	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
32	73	74	75	76	77	78	79	79	[illegible]	[illegible]	[illegible]	[illegible]	84	85	86	86	87	88	89	90
33	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
34	75	76	77	78	79	80	81	82	83	84	85	[illegible]	[illegible]	[illegible]	[illegible]	90	91	92	93	94
36	76	77	78	79	80	81	82	83	85	86	87	[illegible]	[illegible]	[illegible]	[illegible]	92	93	94	95	96
37	77	78	79	80	82	83	84	85	86	87	88	89	90	91	93	94	95	96	97	98
38	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	100
39	79	80	81	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
40	80	81	82	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
41	81	82	84	85	86	88	89	90	91	93	94	95	97	98	99	101	102	103	105	106
42	82	83	85	86	87	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
43	83	84	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110

ALERT

DAGER

EMERGENCY

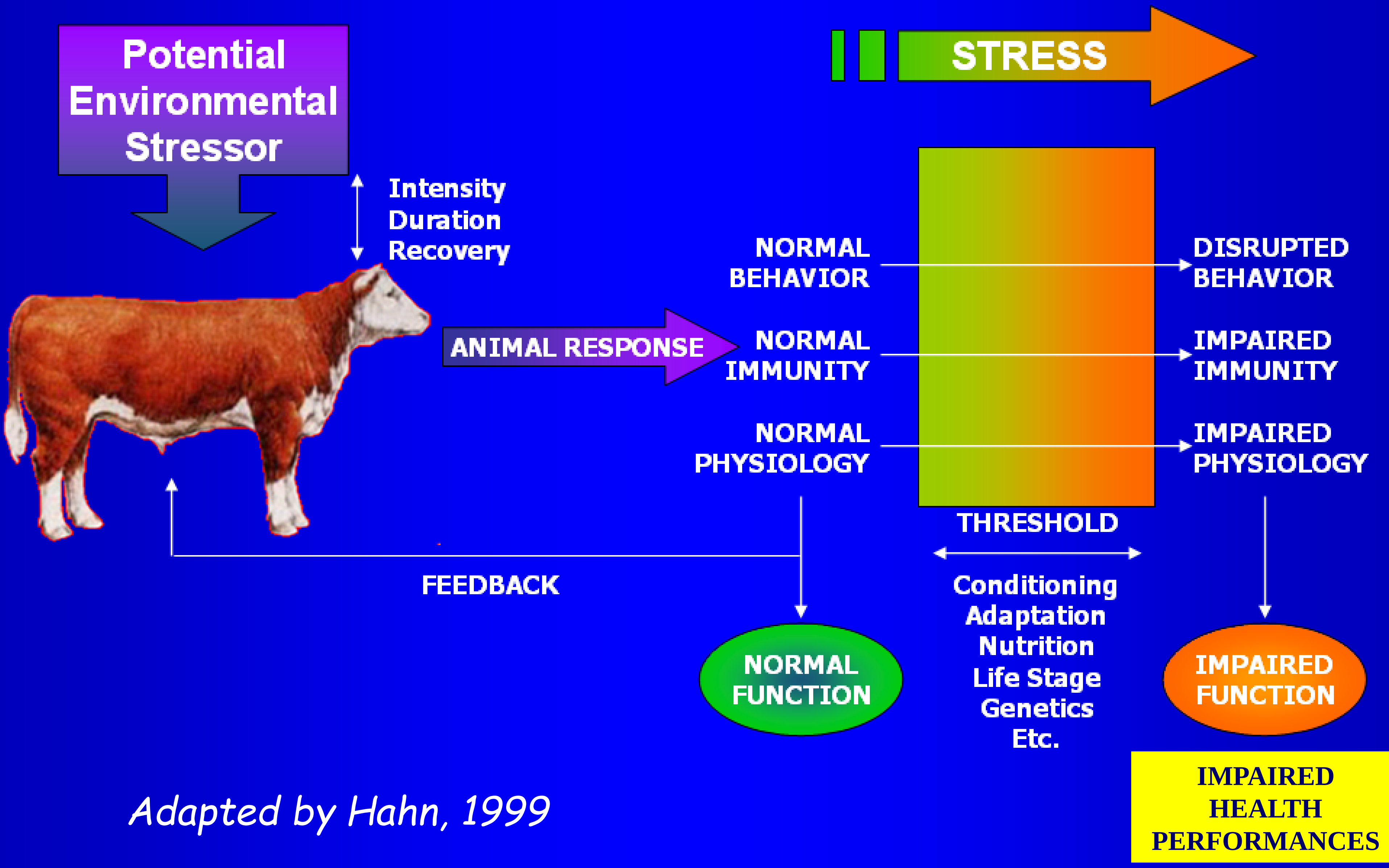
3. Heat Stress

Heat Stress Definition

- Heat stress occurs when the core body temperature of a given species exceeds its range specified for normal activity resulting from a total heat load (internal production and environment) exceeding the capacity for heat dissipation.

- This prompts physiological and behavioural responses to reduce the strain that can modify metabolic responses and lead to physiological disorders.

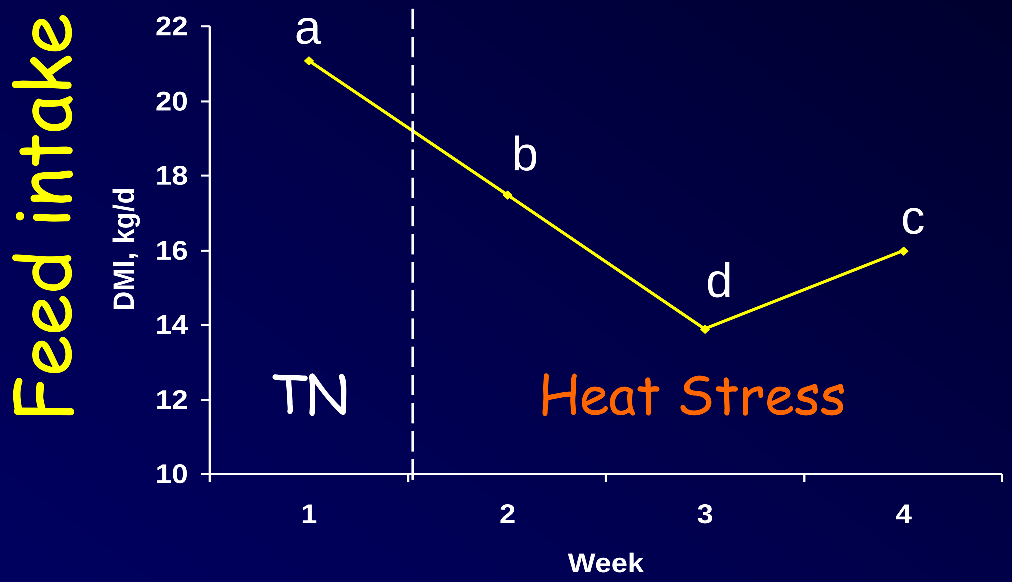
Biological Response

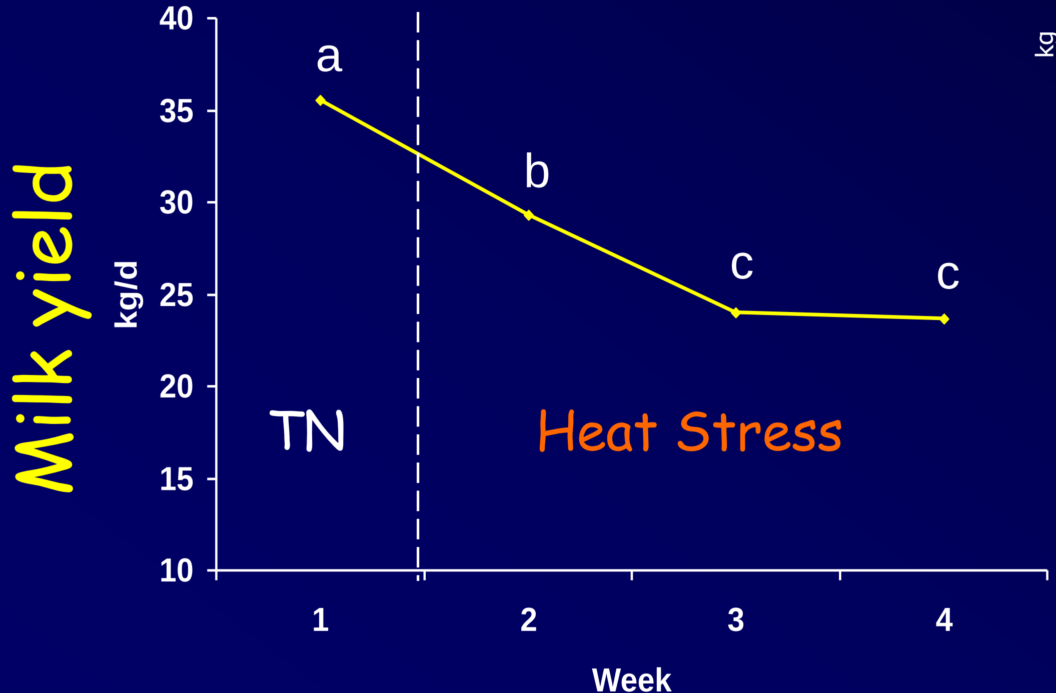


Adapted by Hahn, 1999

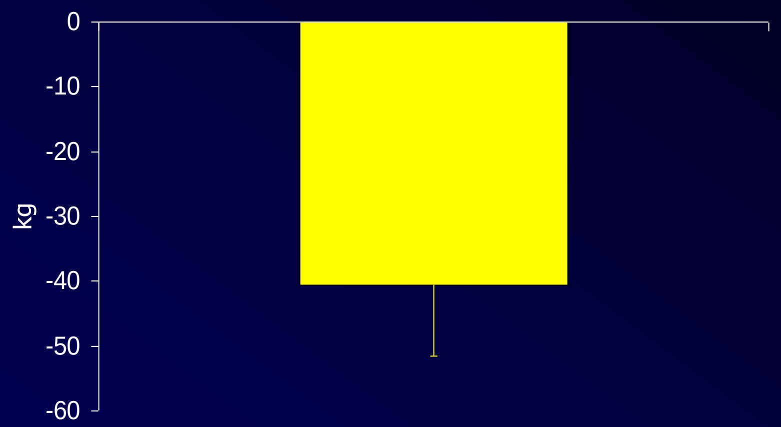
4. Metabolic acclimation to heat stress :

Mid-lactating dairy cows





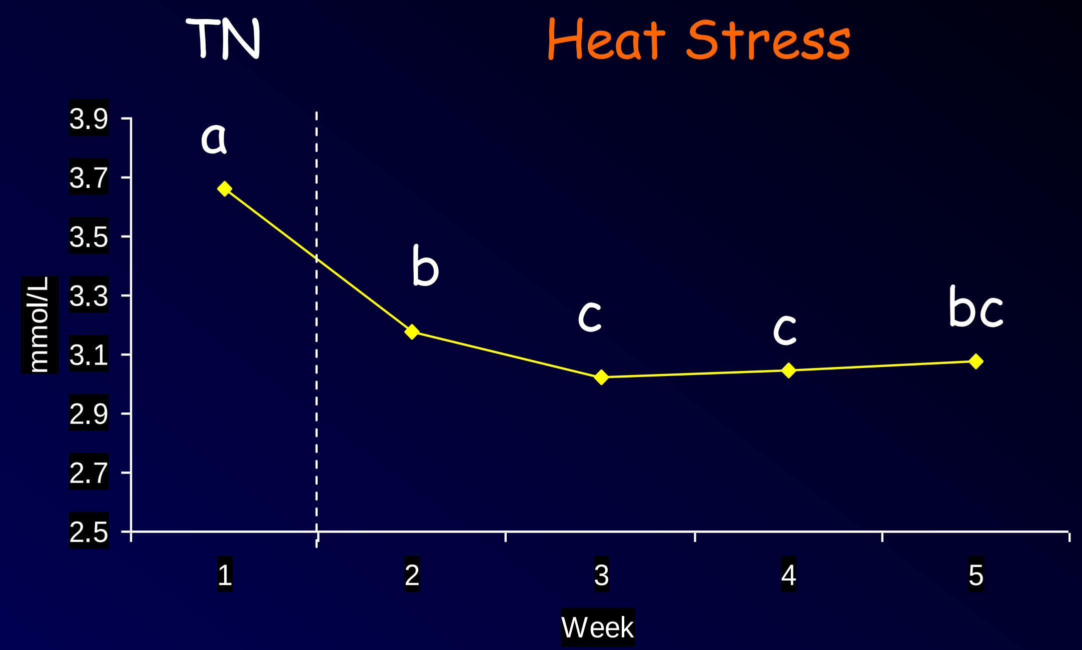
Body Weight Loss
in HS-cows



Shwartz et al., 2009

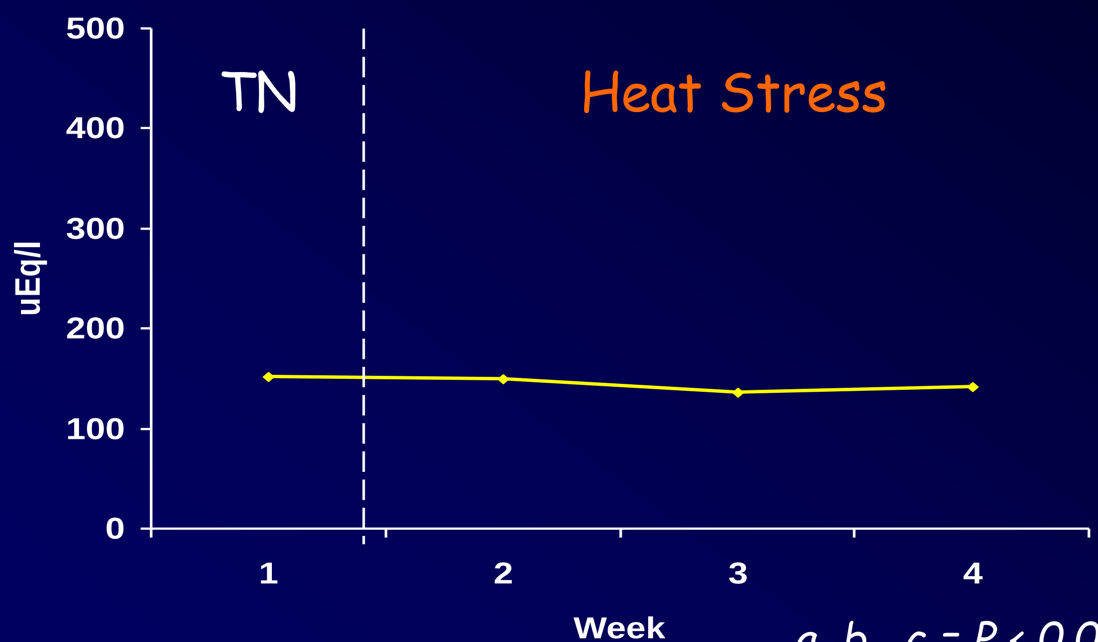
Glucose

(Ronchi et al., 1997)



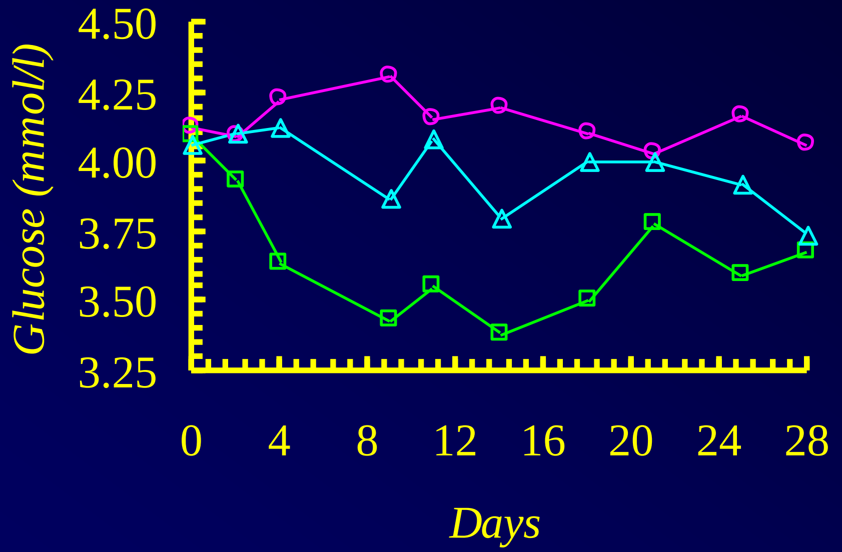
NEFA

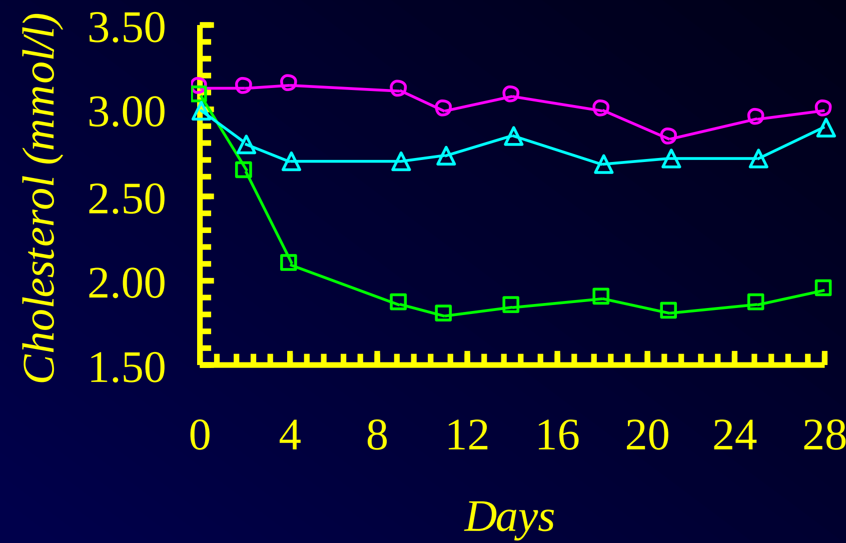
(Ronchi et al., 1997;
Shwartz et al., 2009)



a, b , c = P < 0.05

TN Thermal neutral ad libitum; HS Heat-stressed; TN-PF pair-feed



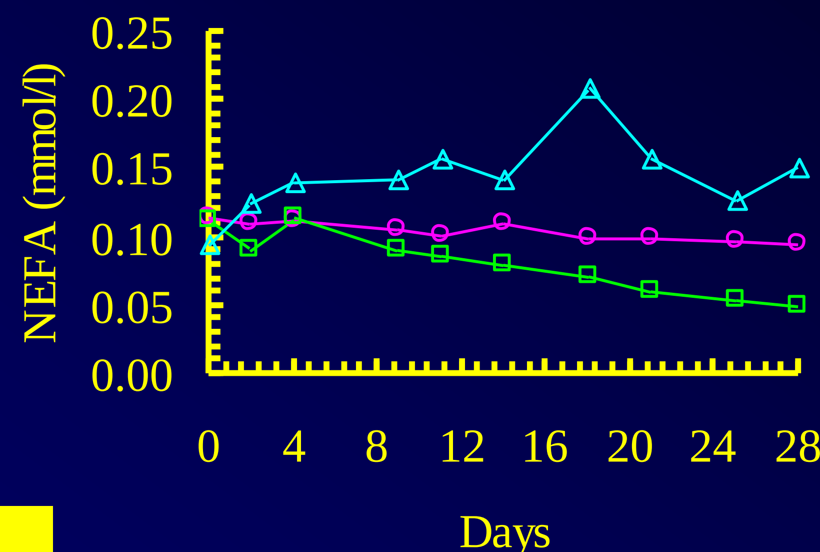


↓Hepatic enzymes

↓ Albumin

↓ Cholesterol

↑ Bilirubine



Reduction of liver metabolic and synthesis activities ?

(*Ronchi et al., 1999*)

Metabolic acclimation
Lactation Trials

- Multiparous Holstein cows (~120 DIM)
- Environmental conditions:

  1) Period 1: thermal neutral conditions (constant 18°C & 20% humidity)

  2) Period 2:

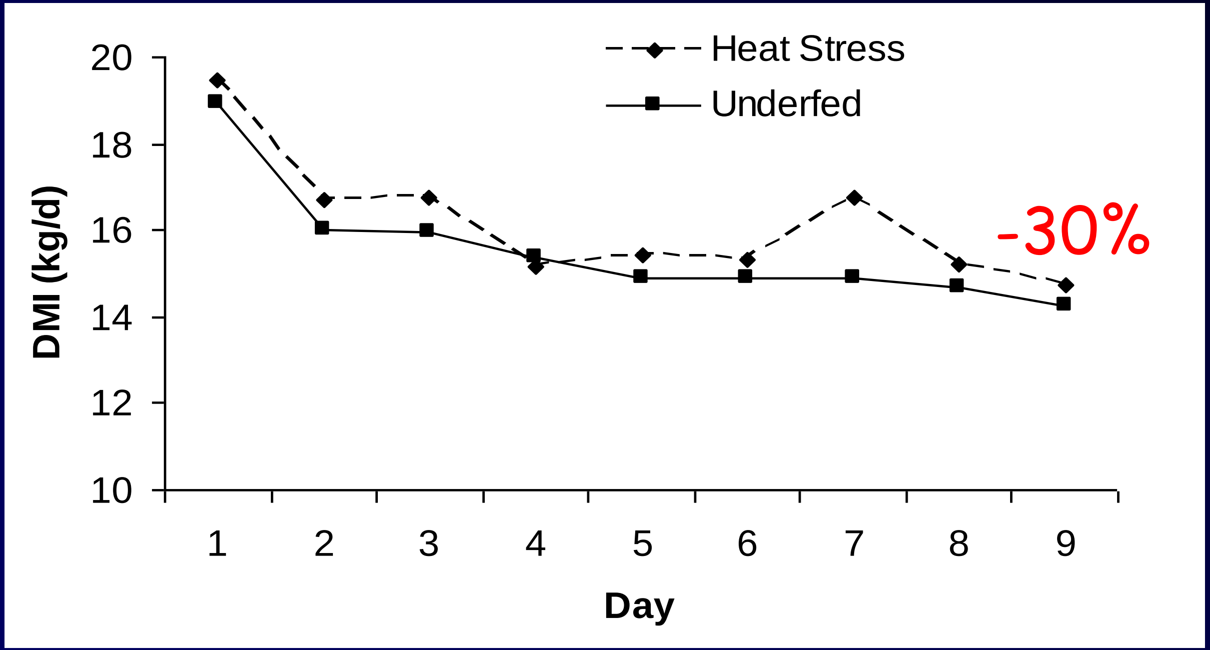
     a) heat stress (cyclical temps 29.4 to 40°C & 20% humidity)

     b) pair-fed*: under thermal neutral with DMI similar to heat stress group

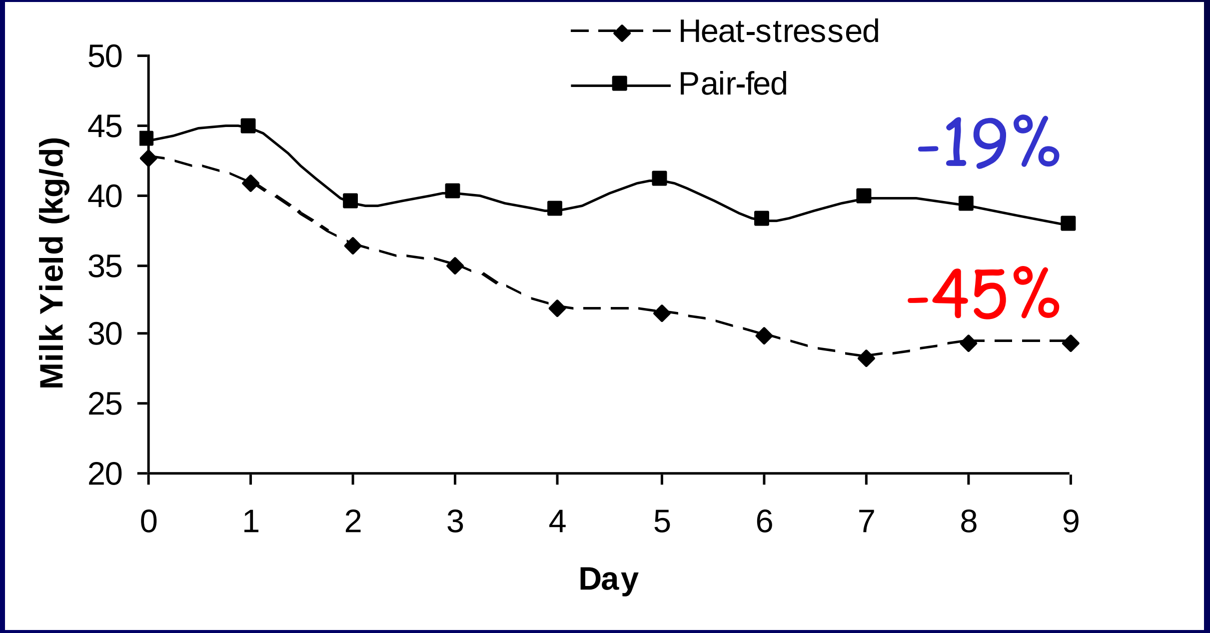
* Pair feeding eliminates confounding effects of dissimilar feed intake

(Wheelock et al., 2010; 2009; Rhoads et al., 2009)

Effects of Heat Stress on Feed Intake and Milk Yield

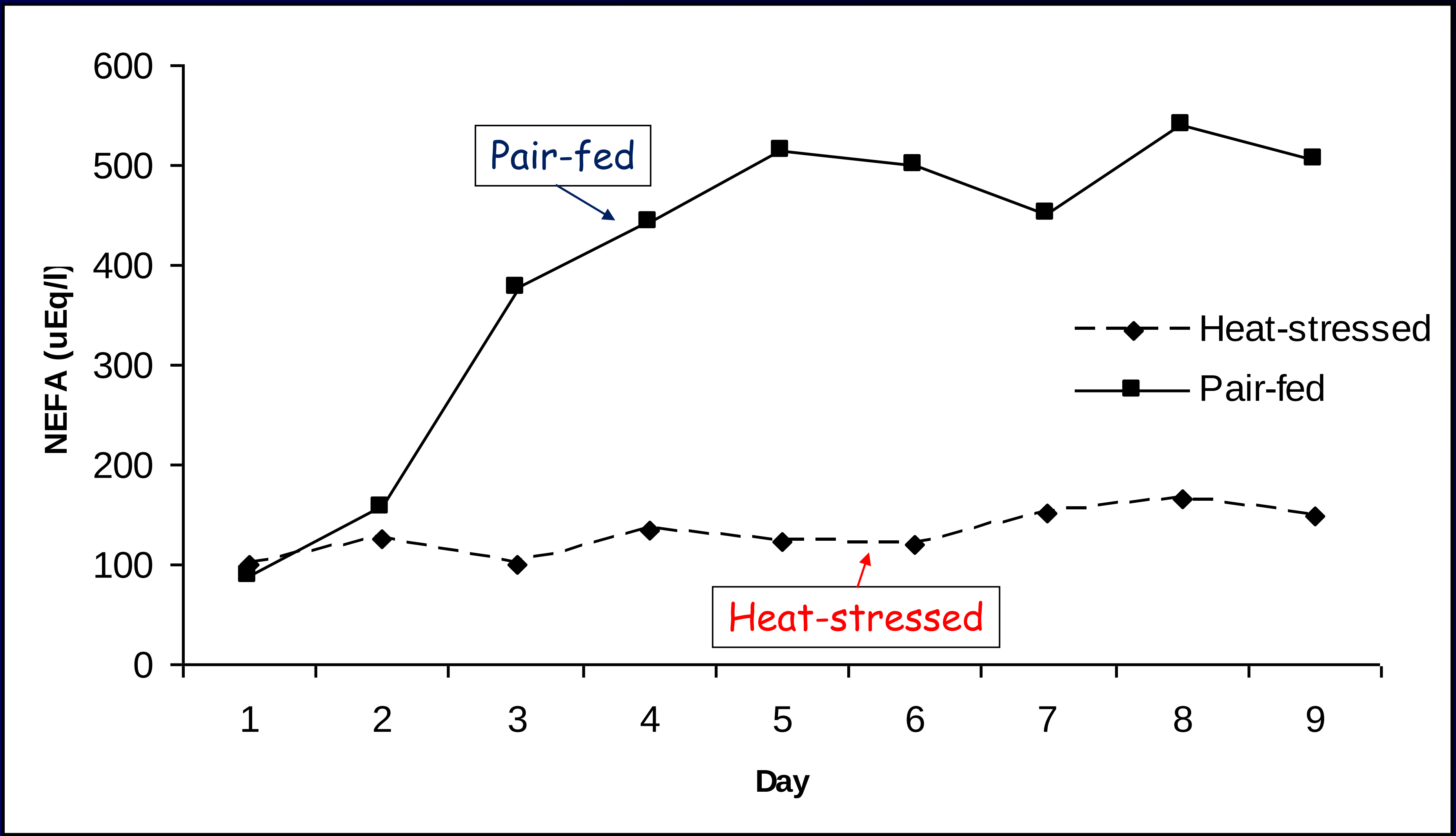


Heat stress ↓ Feed Intake by ~30 %



Thus, ↓ feed intake only accounts for ~50% of the reductions in milk yield

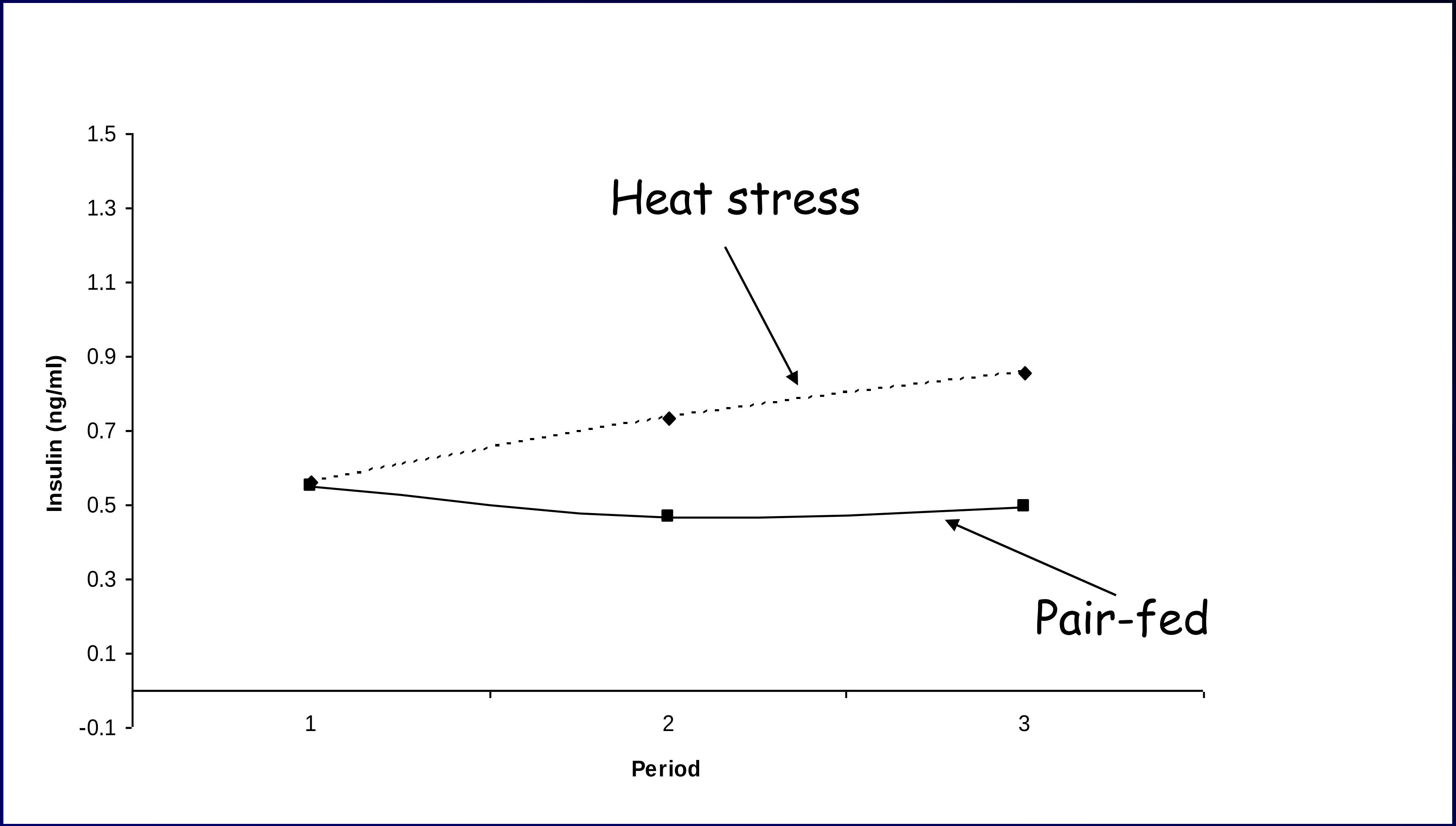
Effects of Heat Stress on Adipose Tissue Mobilization



Rhoads et al., 2009

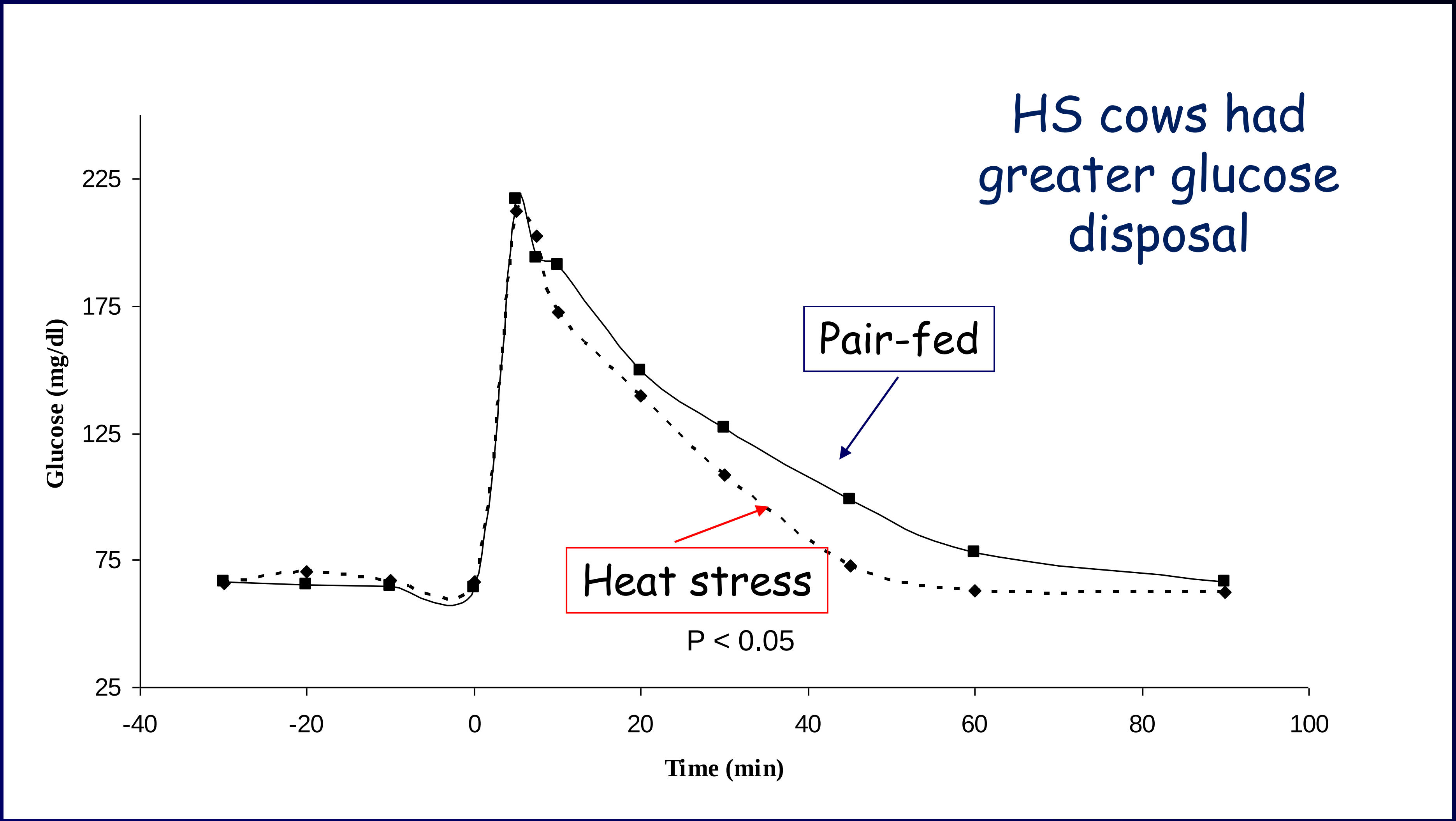
Circulating Insulin

Increased by heat stress independent by feed intake



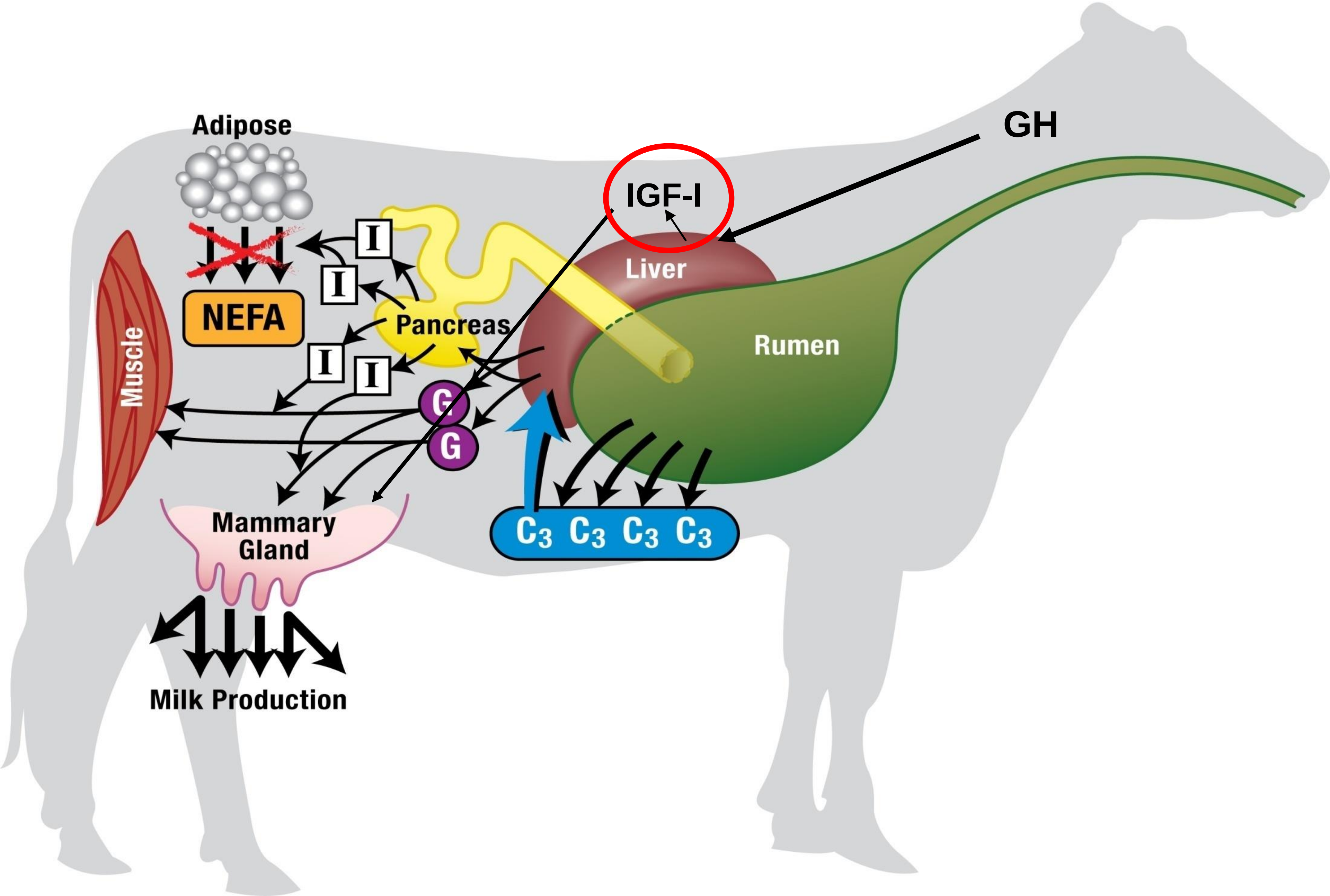
(Wheelock et al., 2010)

Glucose Tolerance Test

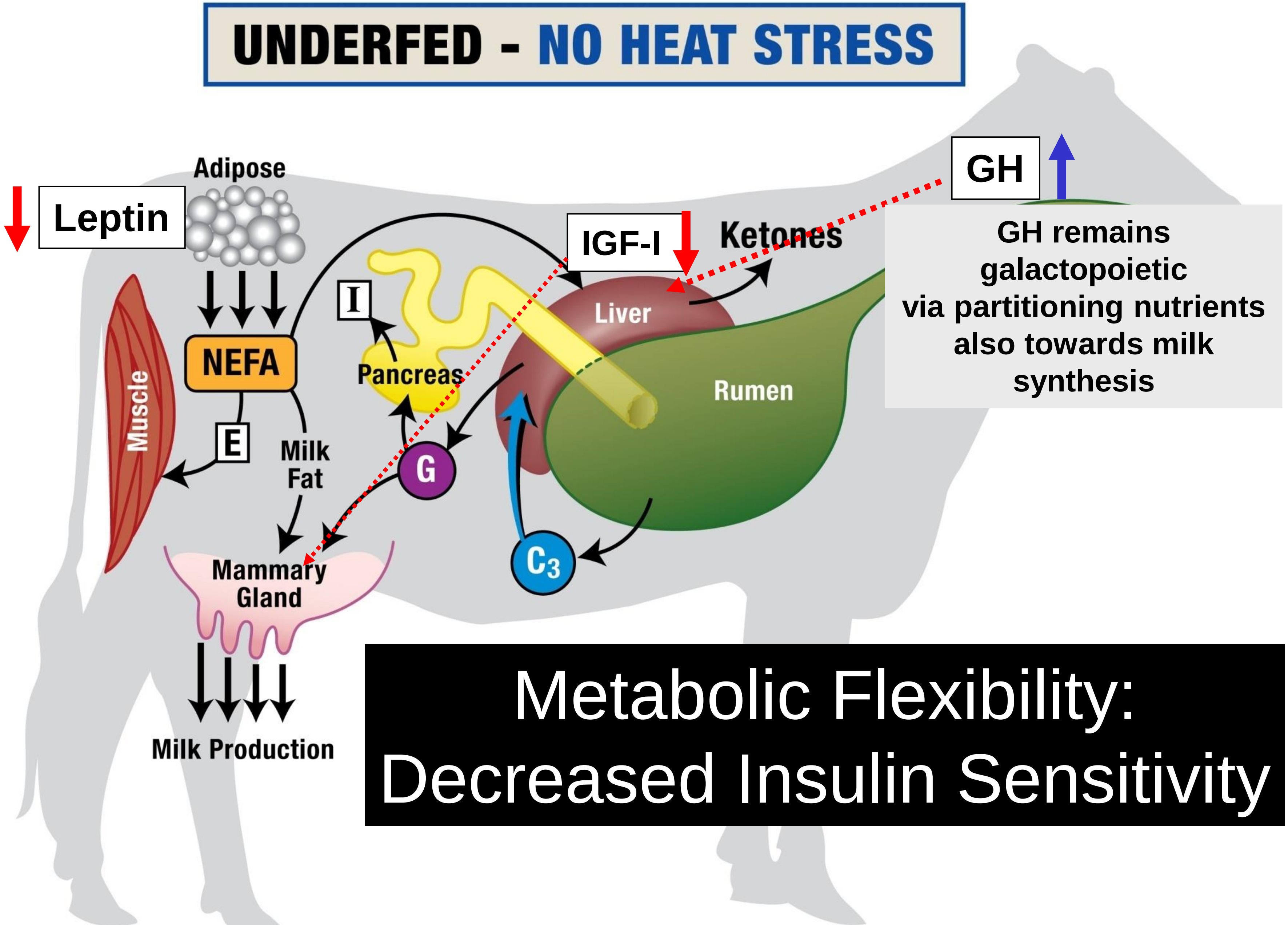


Wheelock et al., 2008

NORMAL - WELL FED



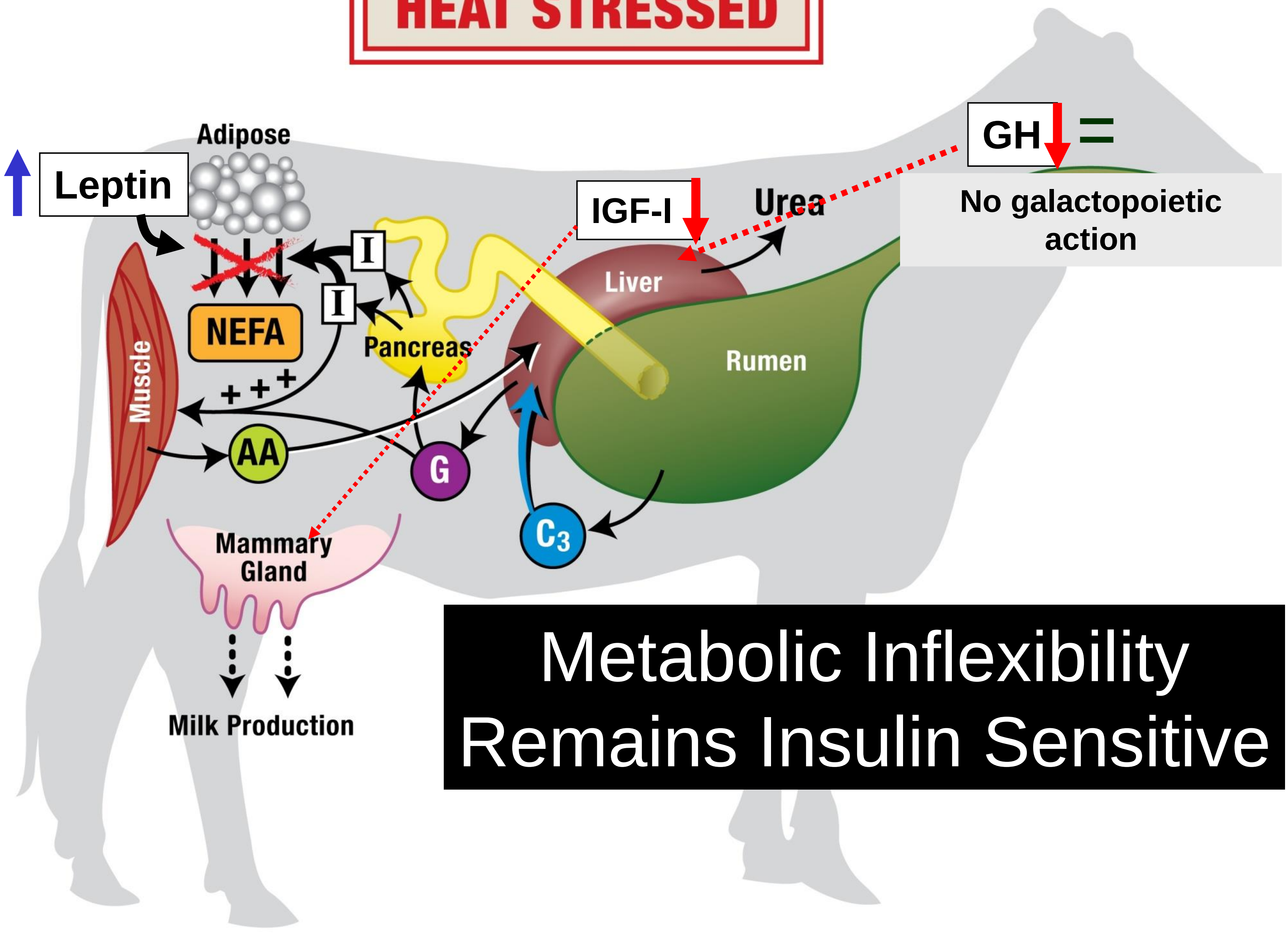
NEBAL



Metabolic Flexibility:
Decreased Insulin Sensitivity

NEBAL

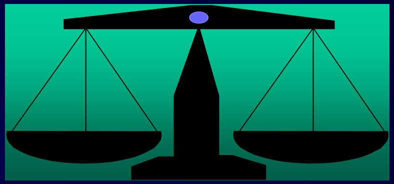
HEAT STRESSED



Metabolic Inflexibility
Remains Insulin Sensitive

Oxidative status

Oxidative stress



Increased* generation of ROS

**From normal aerobic metabolism, activated phagocytes, ionizing radiation, post-ischaemic reperfusion, glycoxidation, cigarette smoke, etc.*

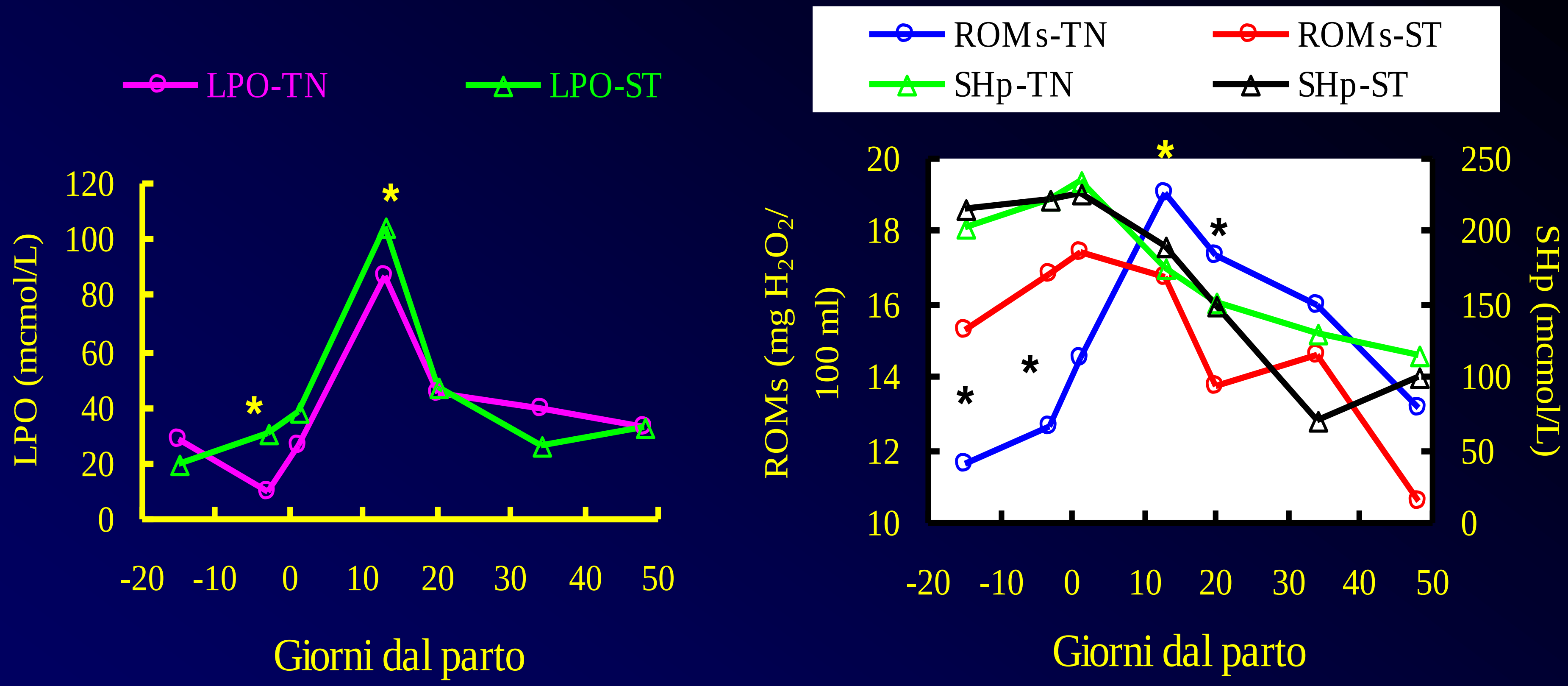
Reduction defences against ROS
- SHp, SOD, GSH, etc..

"An imbalance favoring prooxidants and/or disfavoring antioxidants, potentially leading to damage"

(Sies, 1991)

Oxidative stress and heat stress in transition cows

- ***Harmon et al., 1997***: reduction of antioxidant activity of plasma in HSed mid-lactating cows
- ***Trout et al., 1998***: no effects of HAT on concentration of lipid soluble antioxidants (α-tocopherol, β-carotene, retinol and retinyl palmitate) and on concentration of MDA in muscle
- ***Calamari et al., 1999***: reduction of plasma lipid soluble antioxidants (vitamin E and β-carotene), and increase of plasma TBARs in HSed mid-lactating cows
- ***Bernabucci et al., 2002***: no effects of moderate heat stress on plasma markers of oxidative status



Changes in lipoperoxidation (LPO), reactive oxygen metabolites (ROMs) and thiol groups (SHp) in transitino dairy cows kept under thermoneutral (TN) and heat stress conditions (ST). * = *P<0,05*

Bernabucci et al., 2003

Erythrocyte lipid peroxidation-end products (TBARS), superoxide dismutase activity (SOD), glutathione peroxidase (GSH-Px-E) activity, and intracellular thiols (SH) of summer (SU) and spring (SP) cows during the transition period *(Bernabucci et al., 2002).*

Days from calving		TBARS nmol/ml	SOD U/ml	GSH-Px-E U/ml PCV[1]	SH µmol/ml PCV
-21	SU	8.3 ± 0.4^{B}	176.4 ± 19.8	65.7 ± 3.9^{b}	210.3 ± 56.3^{b}
	SP	7.5 ± 0.4^{A}	141.4 ± 18.8	46.4 ± 3.7^{a}	119.0 ± 53.4^{a}
-3	SU	9.1 ± 0.4^{b}	194.3 ± 20.3^{b}	69.6 ± 4.0	307.9 ± 57.7^{B}
	SP	7.5 ± 0.4^{a}	140.5 ± 20.0^{a}	62.3 ± 4.0	161.5 ± 57.0^{A}
1	SU	10.2 ± 0.4^{B}	215.3 ± 21.3^{b}	59.4 ± 4.2	282.8 ± 60.6^{B}
	SP	7.0 ± 0.4^{A}	179.0 ± 18.8^{a}	56.0 ± 3.7	153.8 ± 53.4^{A}
15	SU	8.6 ± 0.4	192.8 ± 21.3^{b}	62.9 ± 3.9	295.1 ± 60.6^{B}
	SP	8.1 ± 0.4	143.0 ± 18.8^{a}	56.9 ± 3.7	116.2 ± 53.4^{A}
35	SU	8.8 ± 0.4^{b}	153.0 ± 19.8^{b}	56.6 ± 3.9	289.3 ± 56.3^{b}
	SP	7.6 ± 0.4^{a}	172.8 ± 20.0^{a}	52.2 ± 4.0	$139.5 \pm 57.0a$

[1]PCV = packed cells volume

a,b = $P < 0.05$

A,B = $P < 0.01$

Summer conditions capable of producing moderate heat stress cause oxidative stress in transition dairy cows.

An increase of SOD and a concentration of SH in erythrocytes are likely to represent adaptive changes of cows in response to heat stress.

4. Immunity and health

Defensive mechanisms

- Colostrum value
- Immune response

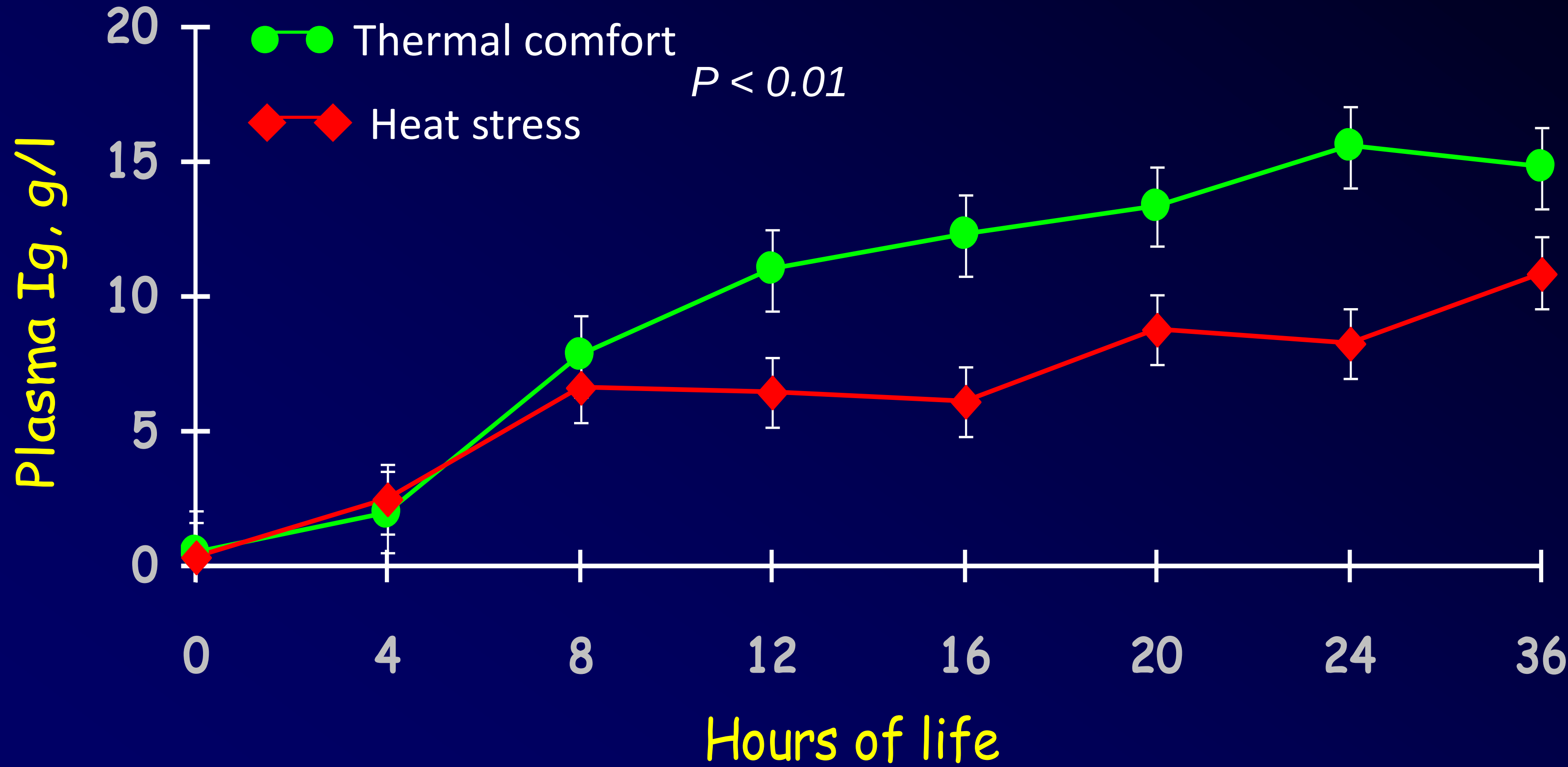
Colostrum protein fractions in cows exposed to thermal comfort (TC) or high air temperatures (HAT) (***Nardone et al., 1997***).

	Hours after calving							
	1		12		24		36	
Item	TC	HAT	TC	HAT	TC	HAT	TC	HAT
IgG, mg/dl	7.925 [b]	6.400 [a]	5.100	4.615	3.357	2.437	1.586	1.260
IgA, mg/dl	400 [d]	210 [c]	238	150	131	107	94	77
CN, %	5.3 [b]	4.3 [a]	3.5 [b]	1.1 [a]	1.6	1.4	1.9	1.7

Ig: immunoglobulins
CN: casein
a, b: P < 0.05; c, d:P < 0.01.

Lacetera et al., 2002: moderate heat stress in diary cows was not associated with changes of colostral Ig or passive immunisation of calves

Post-suckling increase of plasma Ig in newborn calves (*Lacetera, 1998*)



Heat stress and immune response

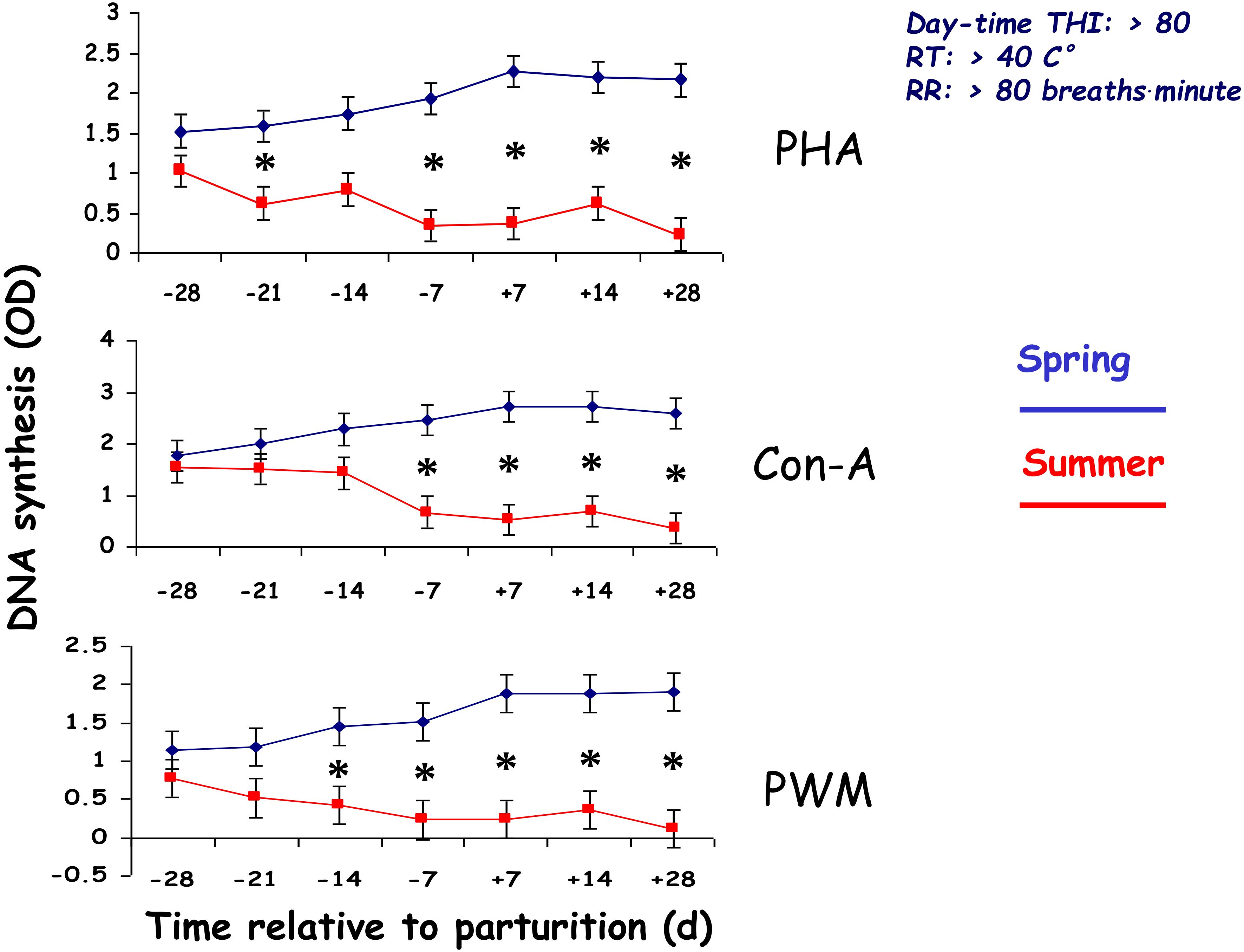
Transition cows

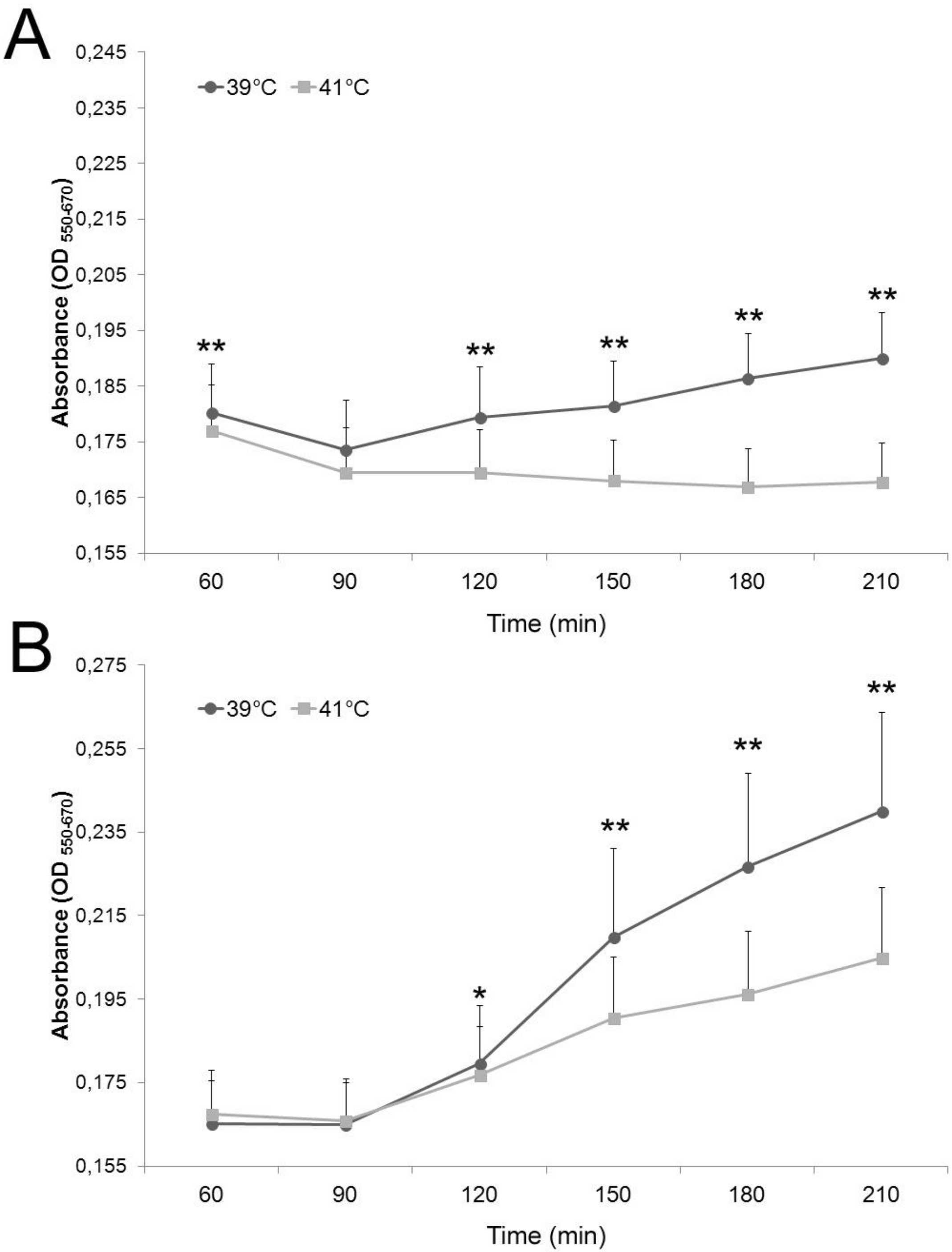
THI data

- **SP**: either day-time (9-20 h) or night-time (21-8 h) THI were below the UCTHI (72)
- **SU**: daytime and night-time THI were 79.5 ± 2.9 and 70.1 ± 4.7, respectively

Heat wave	Duration (d)	Max THI	Mean THI > 72
1	5	83.4	78.9
2	6	85.8	79.1
3	15	90.5	79

(Modified from *Lacetera et al., 2005*)


Day-time THI: > 80
RT: > 40 C°
RR: > 80 breaths·minute
PHA
Con-A
PWM
Spring
Summer
DNA synthesis (OD)
Time relative to parturition (d)
-28
-21
-14
-7
+7
+14
+28
*



Effect of high temperature on bovine PMN generation of extracellular superoxide as measured by cytochrome c reduction.

Resting (A) or PMA-stimulated (B) PMNC were exposed to 39°C or 41°C in the presence of cytochrome c and absorbance values were measured every 30 min. Each assay was carried out in duplicate.

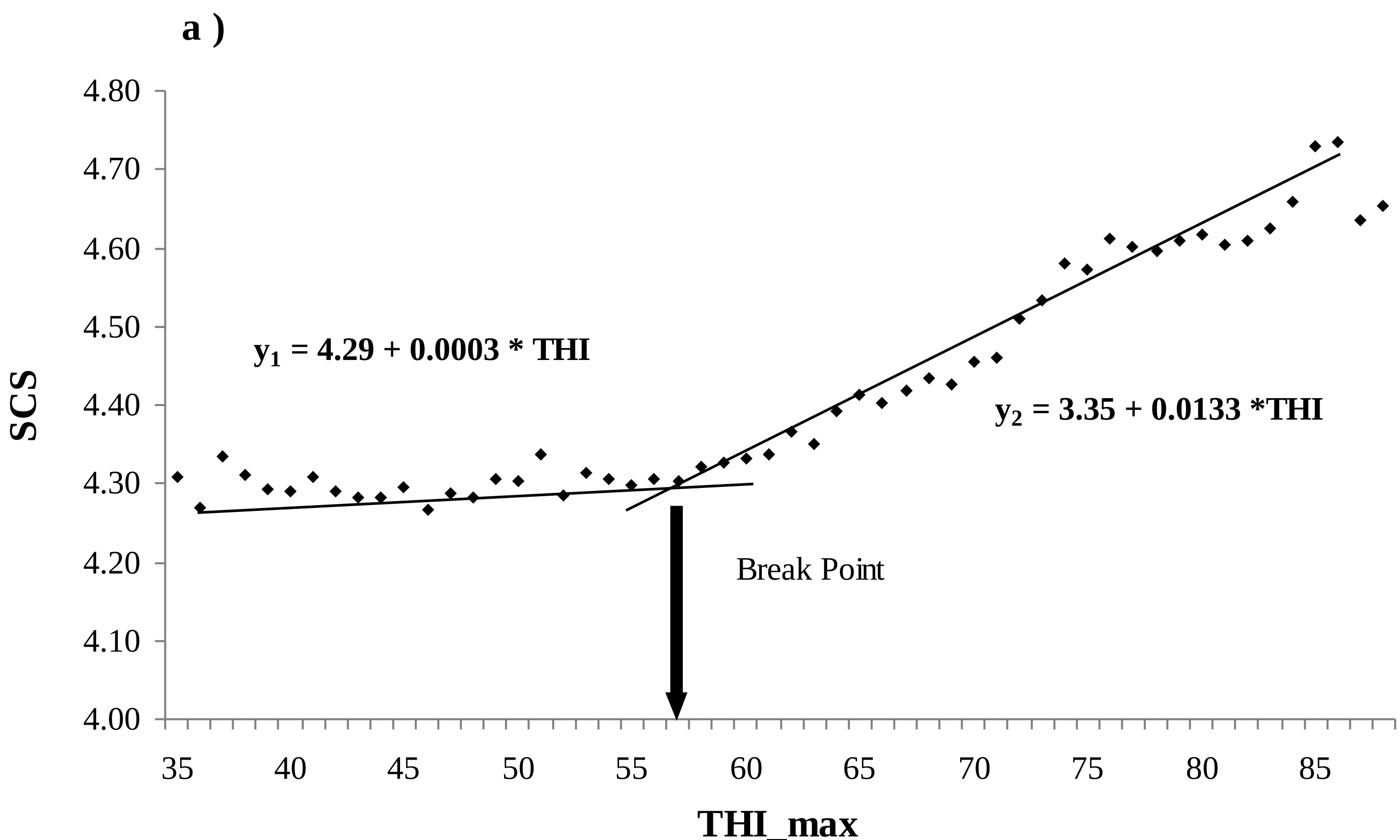
Data are means ± SEM of seven independent experiments.

Significance was declared for $P < 0.05$ (*) and $P < 0.01$ (**).

PMNC activity is strongly altered by heat-shock

A series of studies carried out in dairy cows indicated **higher occurrence of mastitis during periods of hot weather**

(Giesecke 1985; Smith et al. 1985; Morse et al. 1988; Waage et al. 1998; Cook et al. 2002; Yeruham et al. 2003).



(Bertocchi et al., 2014)

Open Access
Asian Australas. J. Anim. Sci.
Vol. 29, No. 8 : 1207-1213 August 2016
http://dx.doi.org/10.5713/ajas.16.0143
www.ajas.info
pISSN 1011-2367 eISSN 1976-5517

Impact of Seasonal Conditions on Quality and Pathogens Content of Milk in Friesian Cows

Mohamed M. A. Zeinhom*, Rabie L. Abdel Aziz[1], Asmaa N. Mohammed[2], and Umberto Bernabucci[3]
Food Hygiene and Control Department, Faculty of Veterinary Medicine, Beni-Suef University, Beni-Suef 62512, Egypt

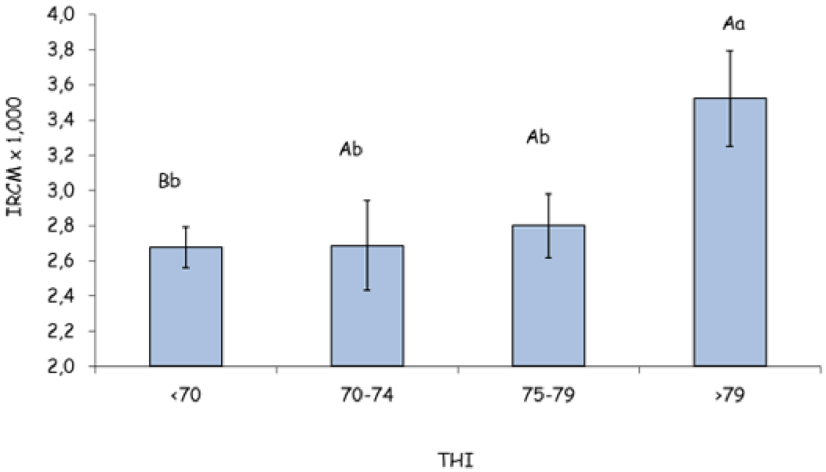
Table 4. Least square means of milk total coliform count, fecal coliform count, *E. coli* count, and *S. aureus* and *E. coli* isolation from milk of Frisian cows exposed to different temperature-humidity index (mxTHI)

	mxTHI<72	mxTHI 72-78	mxTHI>78	RSD
TCC (MPN/mL)	212.9[a]	8,462.0[b]	9147.0[b]	1.56
FCC (MPN/mL)	71.8[a]	4,464.0[b]	5,371.0[b]	1.71
E. coli count (MPN/mL)	17.3[a]	541.3[b]	765.6[b]	1.56
S. aureus, (n/n, %)	6/80 (7.50[a])	16/80 (20.00[b])	43/80 (53.75[c])	NA
E. coli, (n/n, %)	15/80 (18.75[a])	30/80 (37.50[b])	58/80 (72.50[c])	NA

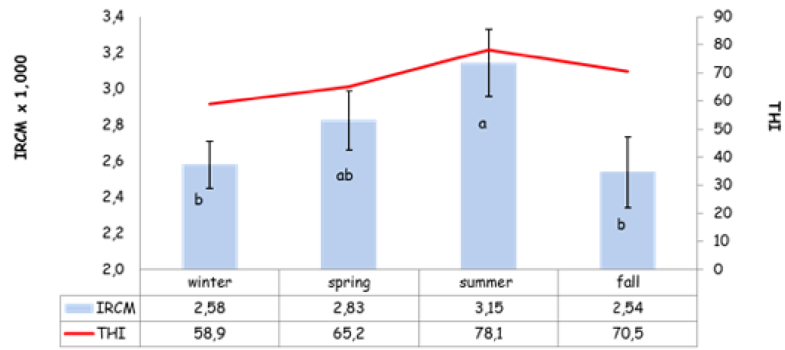
RSD, residual standard deviation; TCC, total coliform count; FCC, fecal coliform count; MPN, most probable number; *E. coli*, *Escherichia coli*; *S. aureus*, *Staphilococcus aureus*; NA, not applicable; n/n = number of positive samples for *S. aureus* and *E. coli* on total samples examined.
[a,b,c] $p<0.001$.

Incidence of mammary infection
(primiparous cows)

Classes of THI



Season

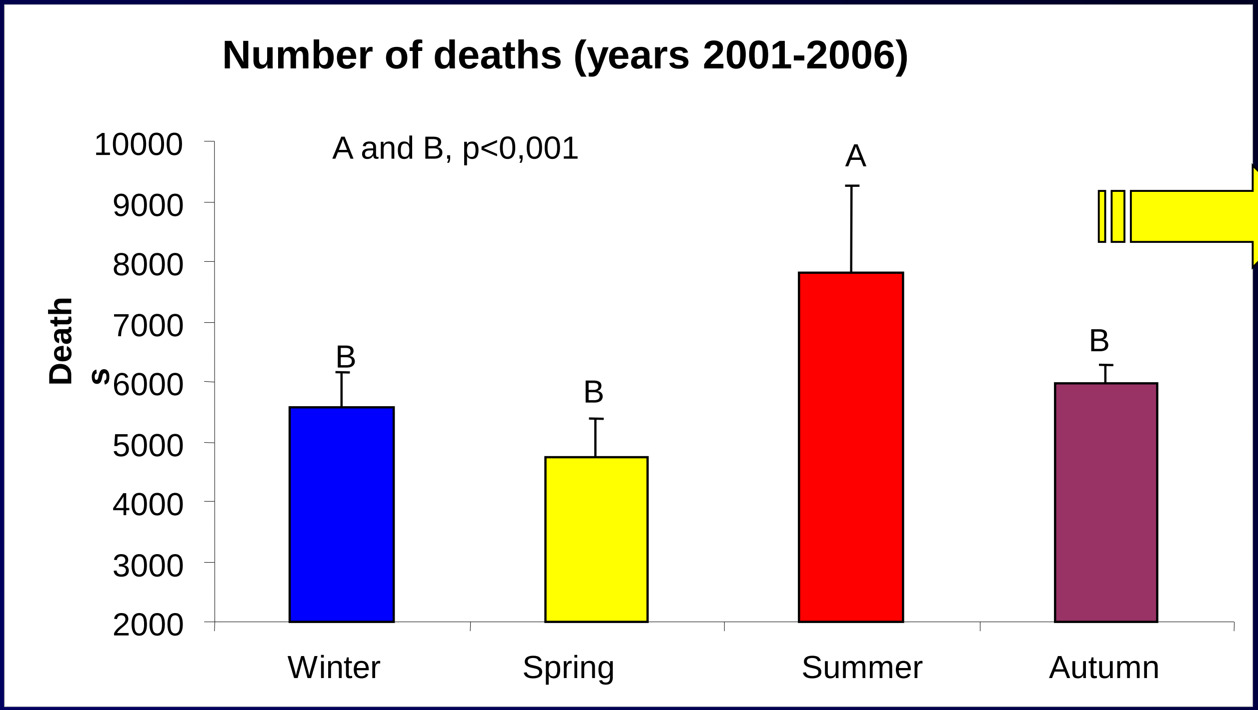


Summary

Heat stress is responsible for:

- the alteration of colostrum composition and passive immunization of calves;
- alteration of immune response;
- greater incidence of mastitis.

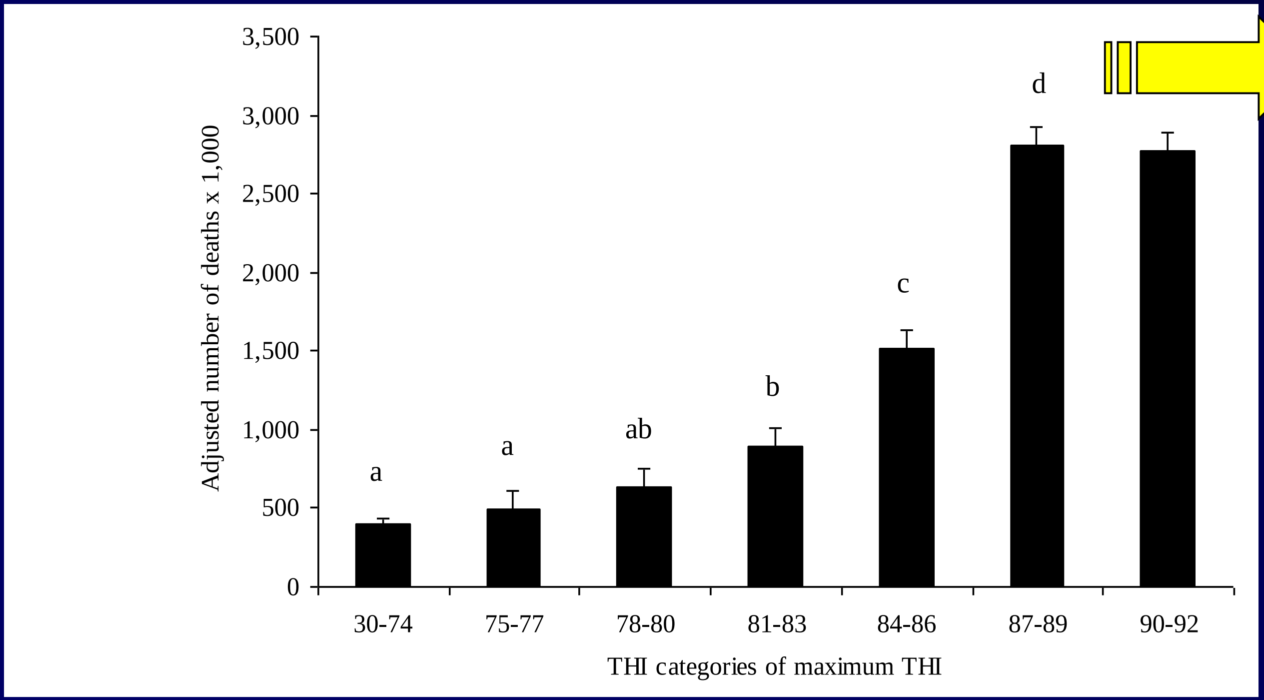
RISK OF DEATH



Seasonal variation

Number of death increased in summer

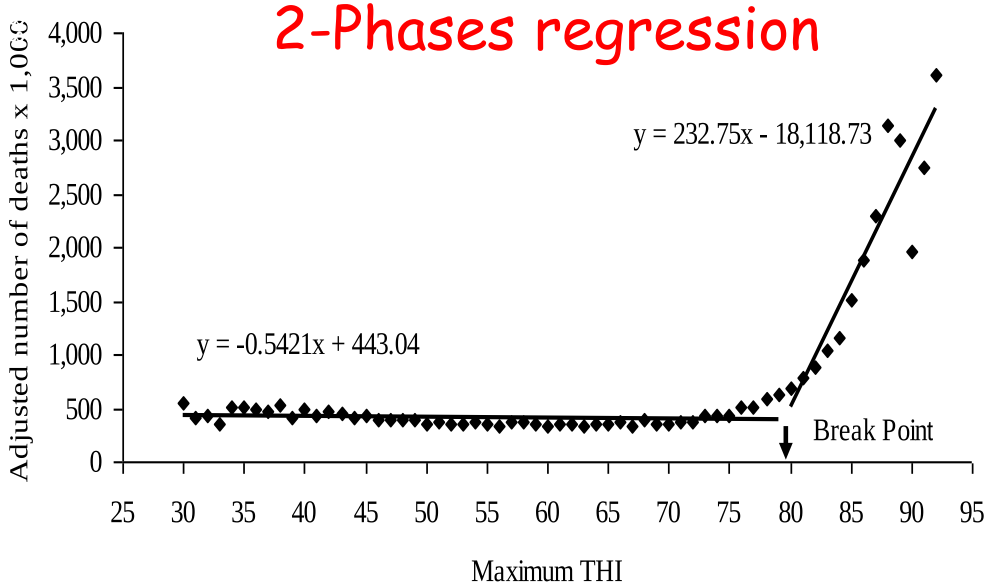
Mortality



Mortality is strongly related with increased THI

Vitali et al., 2009

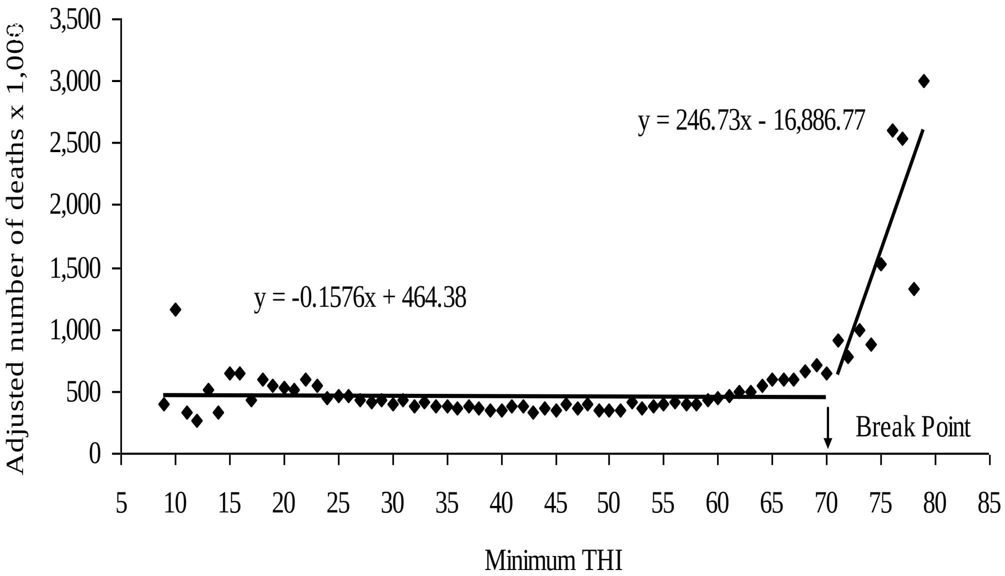
2-Phases regression



Daily maximum THI

Break-point = 80 THI

Similar break-point was reported for beef cattle *(Nienaber and Hahn, 2007)*

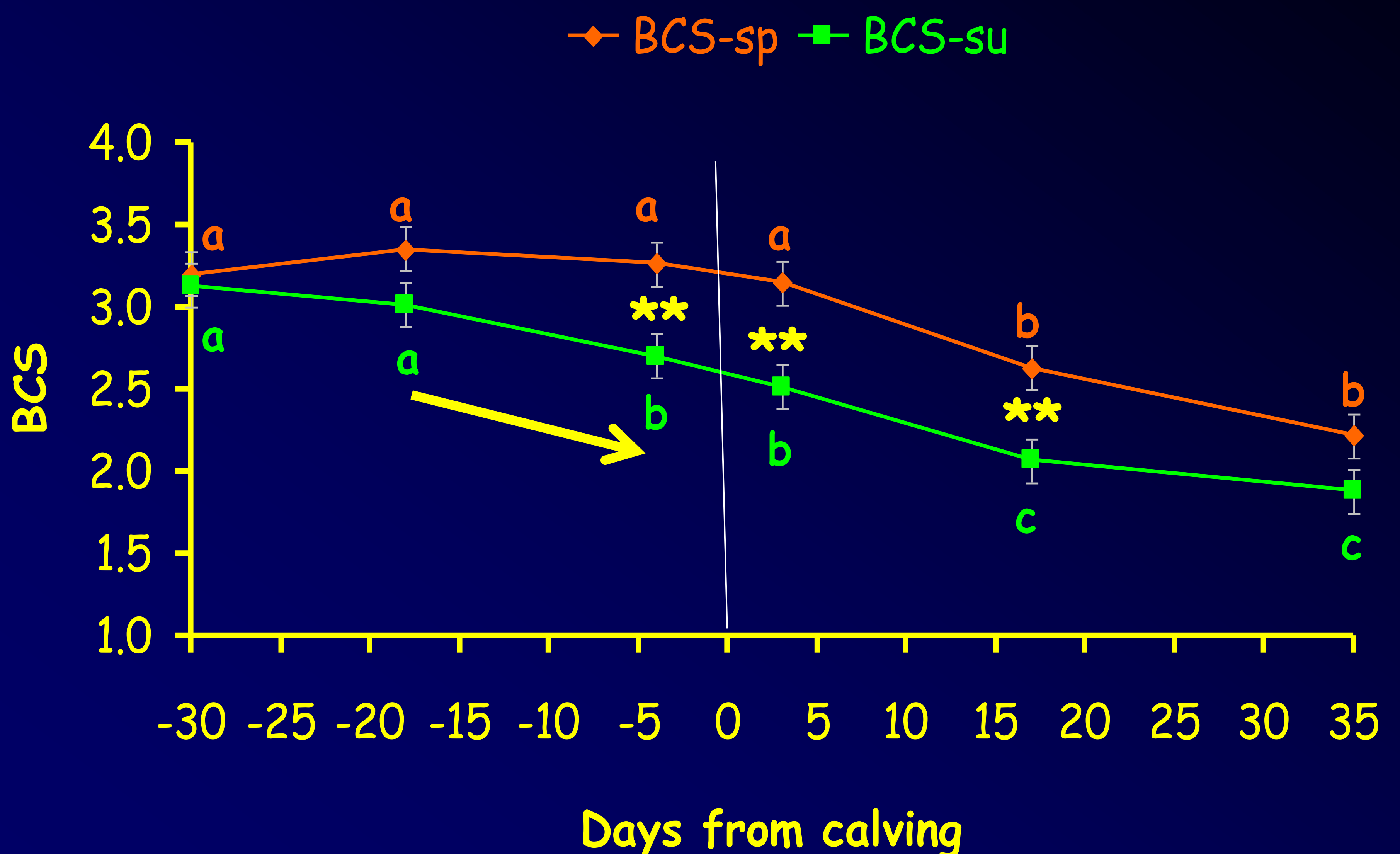


Daily minimum THI

Break-point = 70 THI

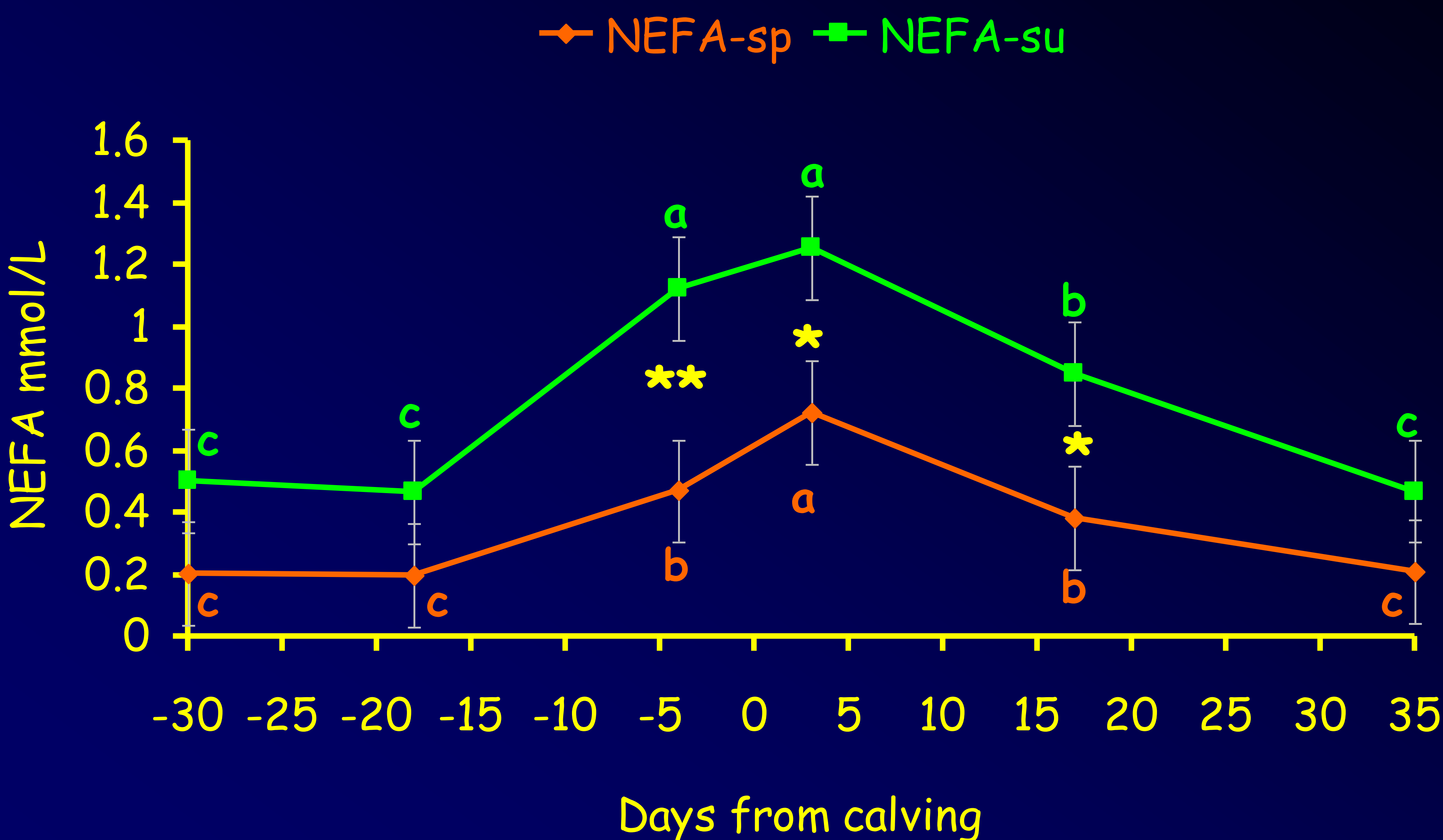
Vitali et al., 2009

BCS changes in spring and summer cows



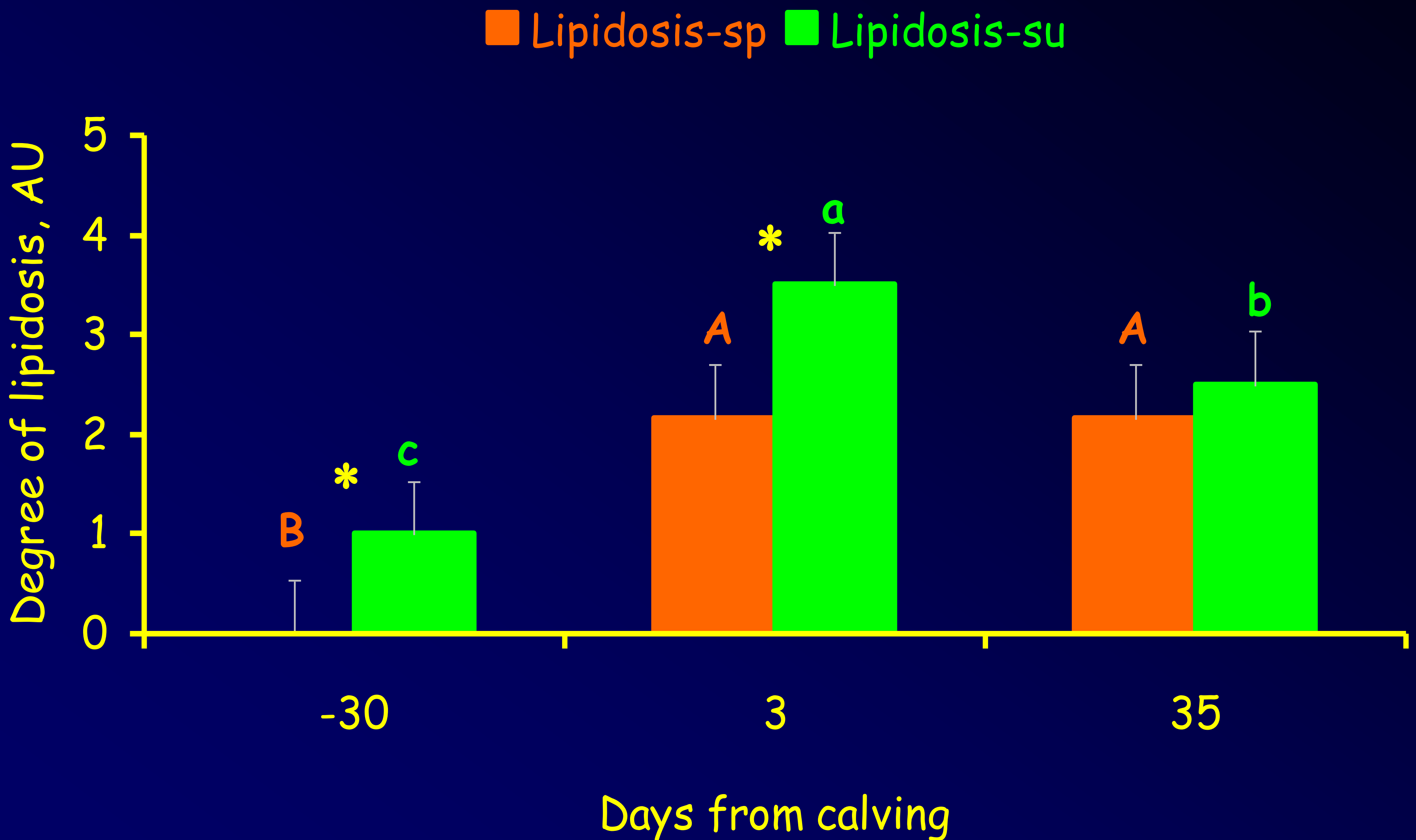
A, B,C = *P* < 0.01 a, b, c, d = *P* < 0.05 within season *P < 0.05 **P < 0.01 within time

Plasma NEFA concentrations in SP and SU cows



A, B,C = *P* < 0.01 a, b, c, d = *P* < 0.05 within season *P < 0.05 **P < 0.01 within time

Lipid accumulation in liver of SP and SU cows



A, B,C = *P* < 0.01 a, b, c, d = *P* < 0.05 within season *P < 0.05 **P < 0.01 within time

Correlation analysis ‘r_s’ in heat-stressed cows

	Degree of lipidosis
$ApoB_{100}$ mRNA	-0.49
$ApoB_{100}$ liver protein	-0.37
$ApoB_{100}$ plasma protein	-0.47
NEFA	0.58

r_s= Spearman Rank Ordinal Correlations

5. Reproduction

Seasonal heat stress

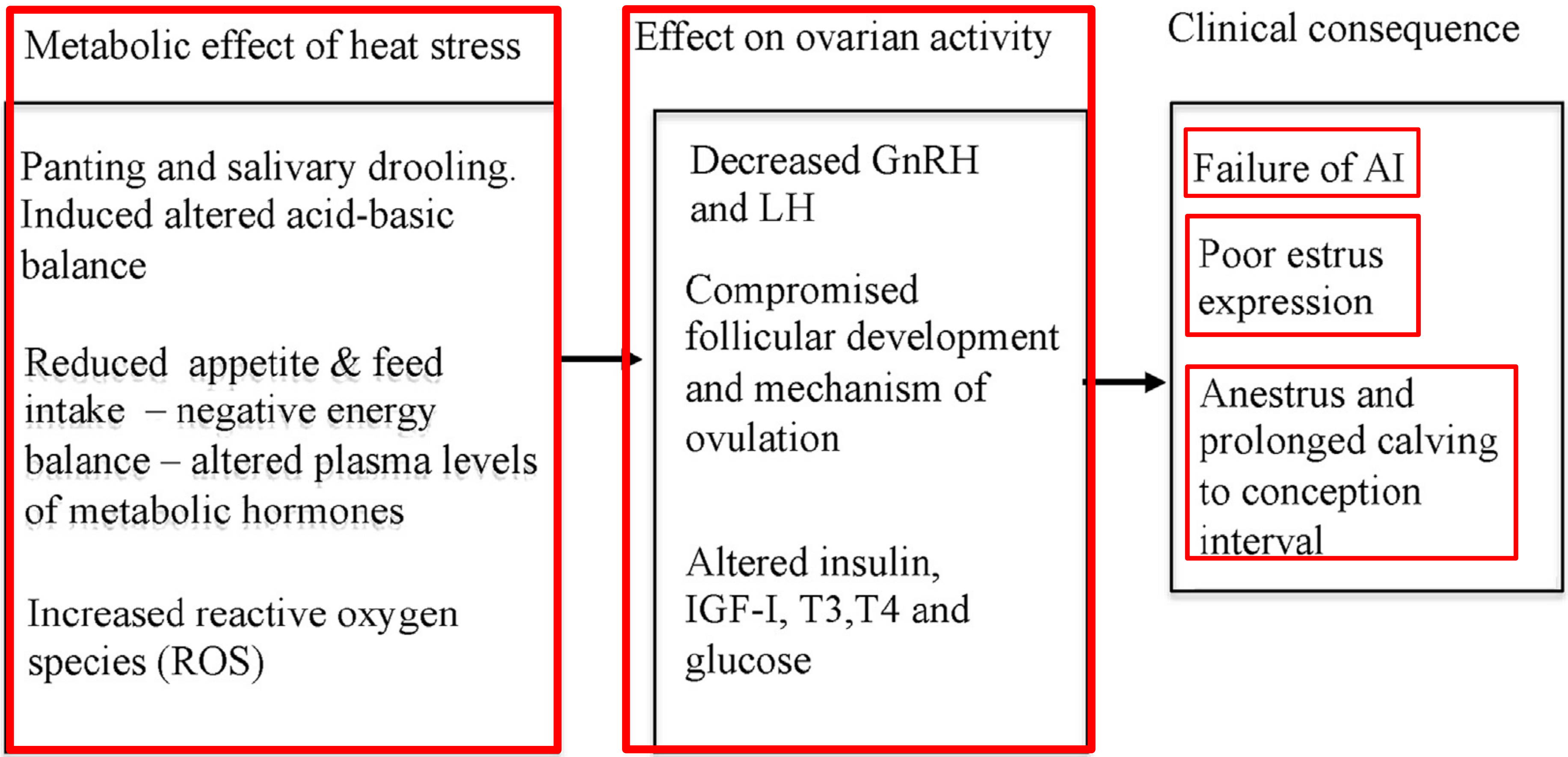
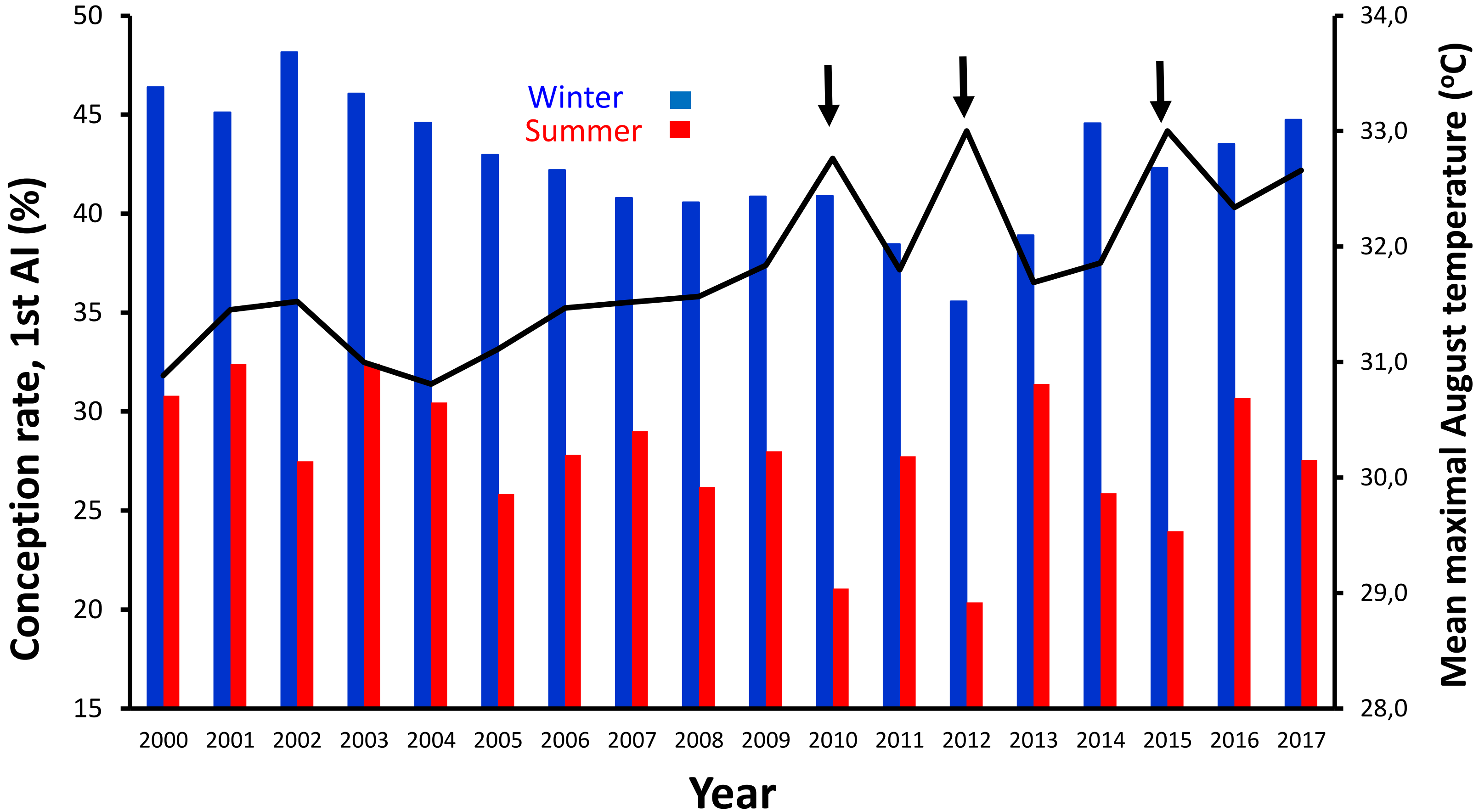


Fig. 1. The main metabolic mechanisms that effect reproduction during periods of seasonal heat stress in dairy cows.

De Rensis et al., 2017. Theriogenology 91:145-53

Conception rates in large dairy farms in Israel of cows first inseminated during the winter (January - March) or summer (July - September) of 2000 to 2017. Mean maximal air temperatures during August months of each year are presented as a black curve. Extreme summer conditions in 2010, 2012 and 2015 are associated with markedly lower conception rates. Y. Lavon and E. Ezra, Israel Herd Book, (Wolfenson and Roth, 2019).



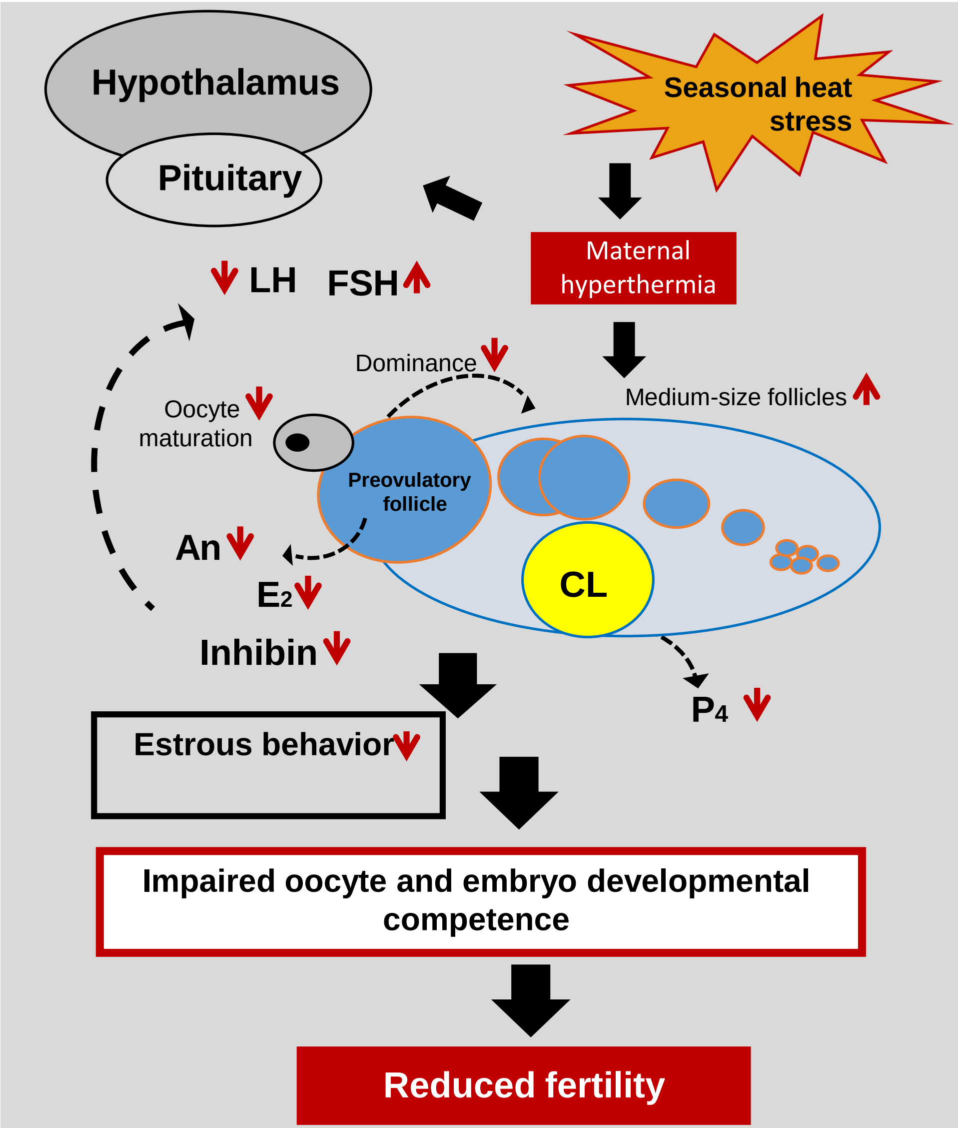
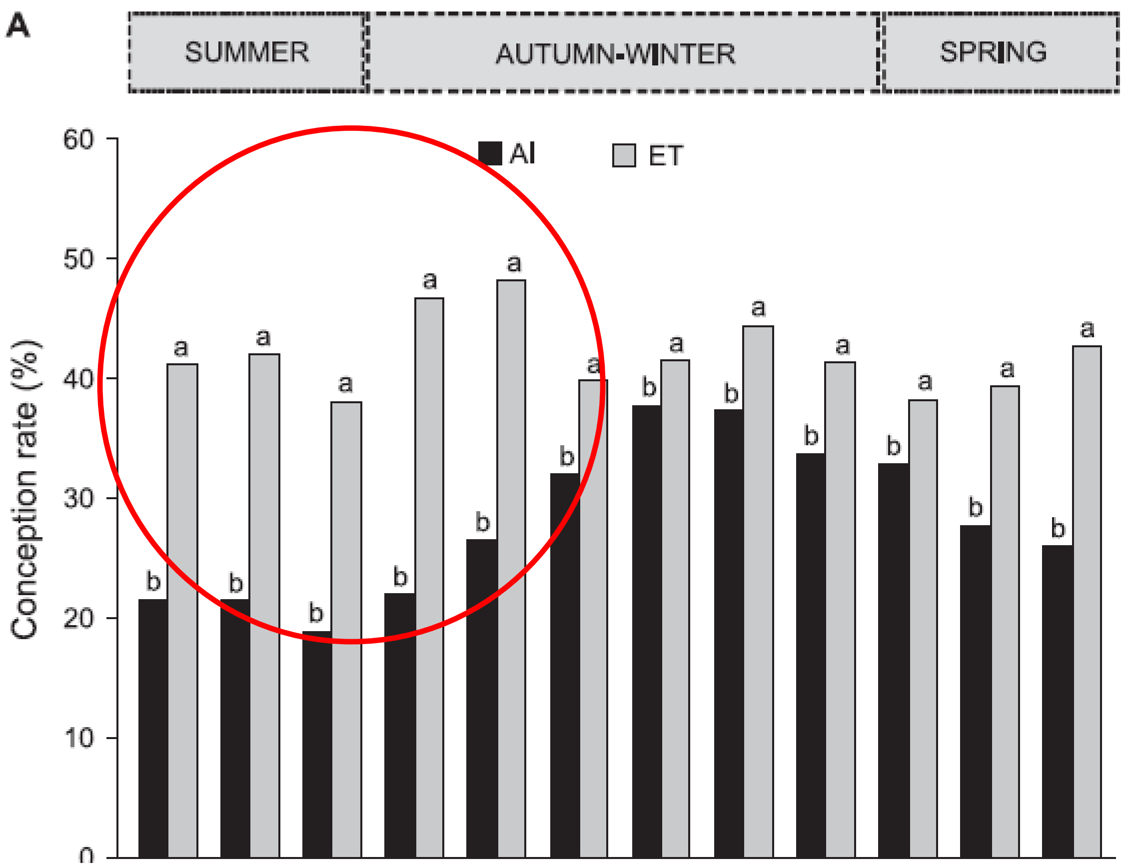


Diagram illustrating the long-term effects of seasonal heat stress on the hypothalamus-pituitary-ovarian axis and its involvement in reducing fertility of lactating cows. Reduced LH secretion is associated with reduced follicular estradiol (E2) secretion. Reduced dominance of the preovulatory follicle is reflected by reduced androstenedione (An) and E2 concentrations and is associated with reduced estrous behavior. Increased number of medium-size follicles (6–9 mm in diameter), most likely due to reduced dominance, is associated with reduced inhibin and increased FSH concentrations. Reduced oocyte and embryo developmental competence is associated with disruption of nuclear and cytoplasmic maturation. Reduced plasma progesterone (P4) concentration is related to impaired function of the CL. Reduced fertility in heat-stressed cows is presumed to result from additive effects.

Wolfenson and Roth, 2019

CONCEPTION RATES OF HIGH-PRODUCING HOLSTEIN COWS SUBMITTED TO AI OR ET



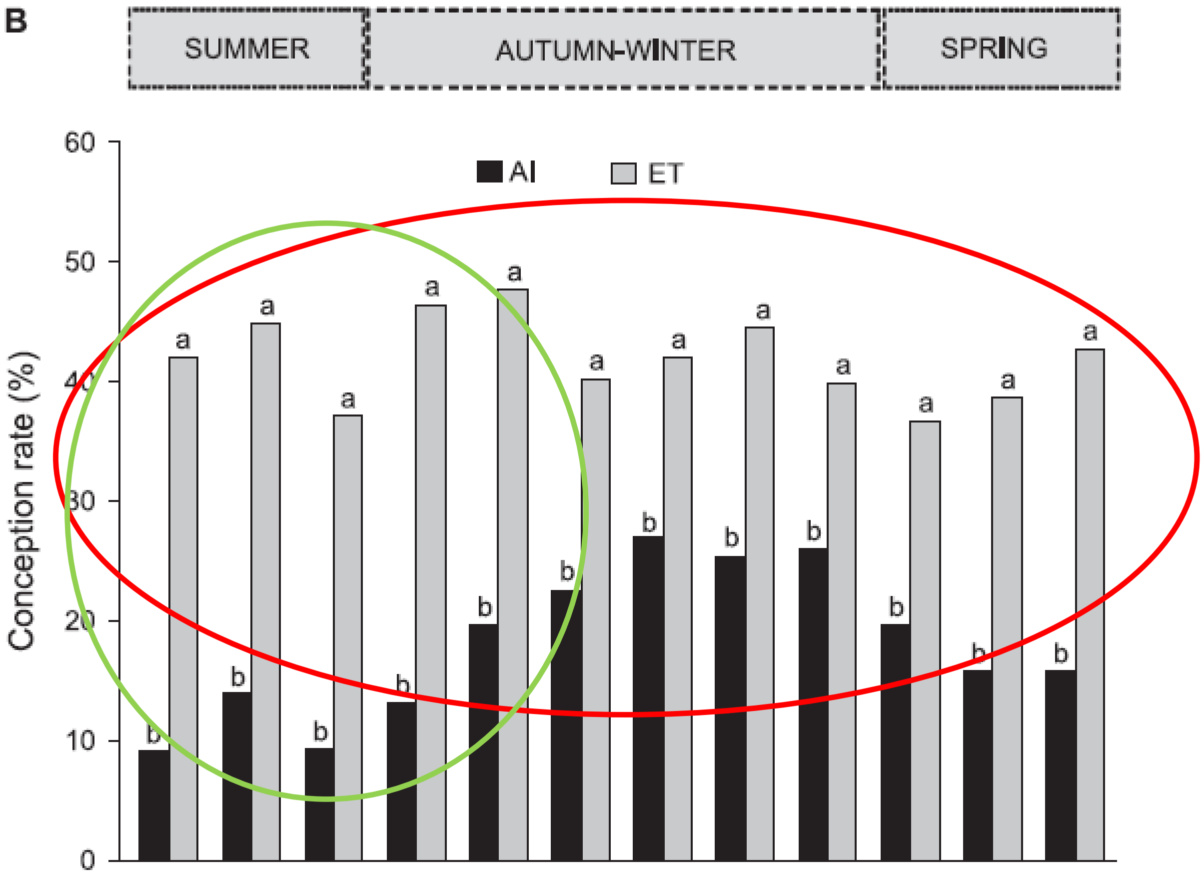
12.875 AI and **4822 ET** during 4 year period

CR AI ~ 29% (19-38%)
CR ET ~ 42% (38-48%)

DURING SUMMER AND EARLY AUTUMN :
CR AI ~ 21%
CR ET ~ 42%

Baruselli PS et al. 2011. Theriogenology 76:1583-1593.
Rodrigues CA et al. 2007 Acta Sci Vet 33:1254(Abs).

CONCEPTION RATES OF HIGH-PRODUCING REPEAT BREEDERS HOLSTEIN COWS SUBMITTED TO AI OR ET



5693 AI and **3858 ET** during 4 year period

DURING THE YEAR:
CR AI ~ 18% (9-27%)
CR ET ~ 42% (36,7-47,7%)

A repeat breeder is a cow that is cycling normally, with no clinical abnormalities, but has failed to conceive after at least two successive inseminations.

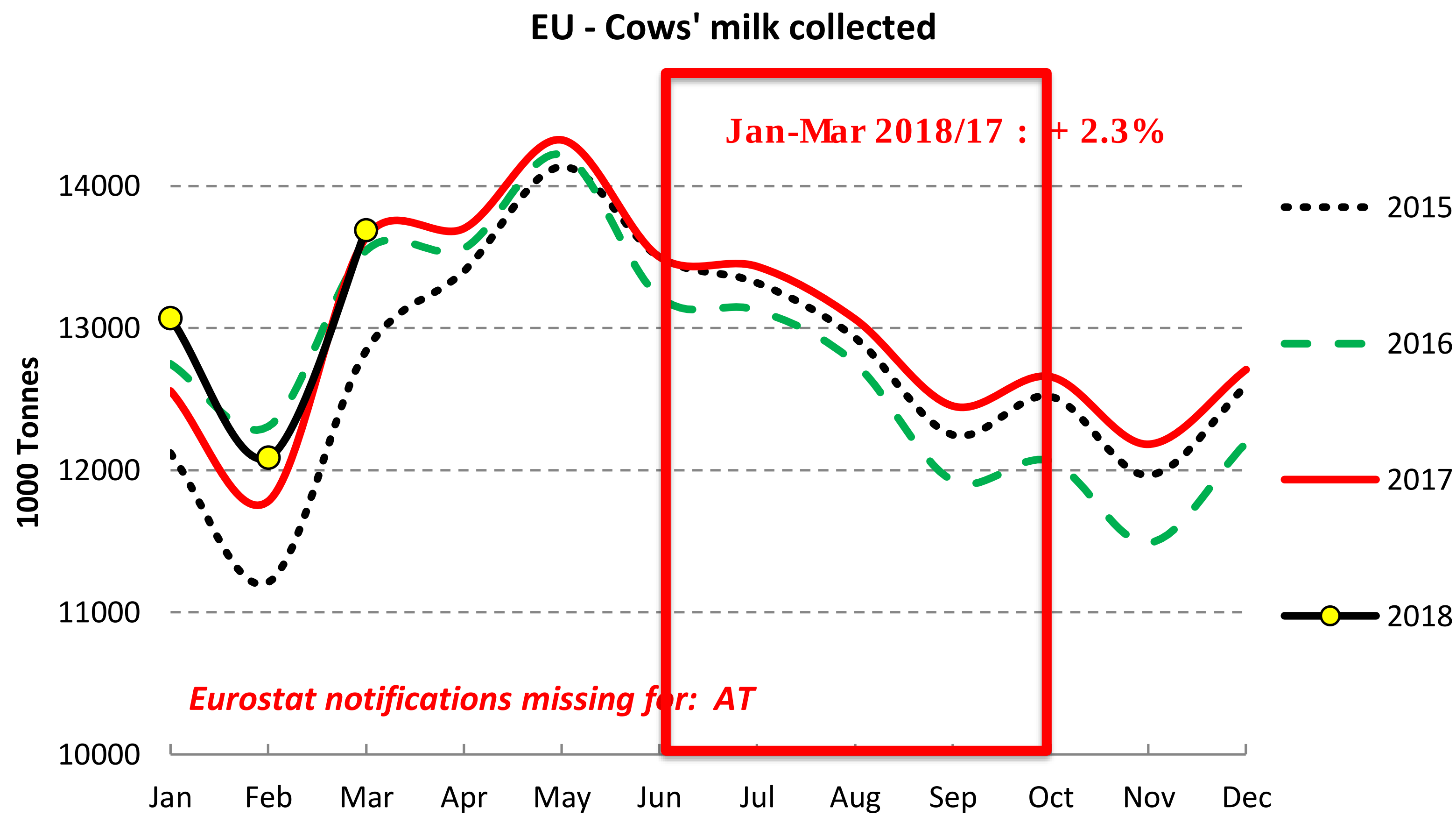
- Summer heat stress is a major cause of low fertility in dairy cattle. Consequently, cows are unable to conceive.

- Severe hyperthermia results from high metabolic heat production and low rate of evaporative heat loss. This compromises dairy cow reproduction through a chain of complex mechanisms (metabolic, hormonal and cellular)

- Multiple reproductive processes are impaired, including oocyte competence, embryonic growth, gonadotropin secretion, ovarian follicular growth steroidogenesis, development of the corpus luteum , and uterine endometrial responses.

- Treatments combined with cooling may improve fertility. Combinations of GnRH and PGF2α are used to improve fertility. Embryo transfer and progesterone supplementation also improve fertility of subpopulations of cows.

6. Milk production



Source : Estat - Newcronos

Last update : Jan-Mar

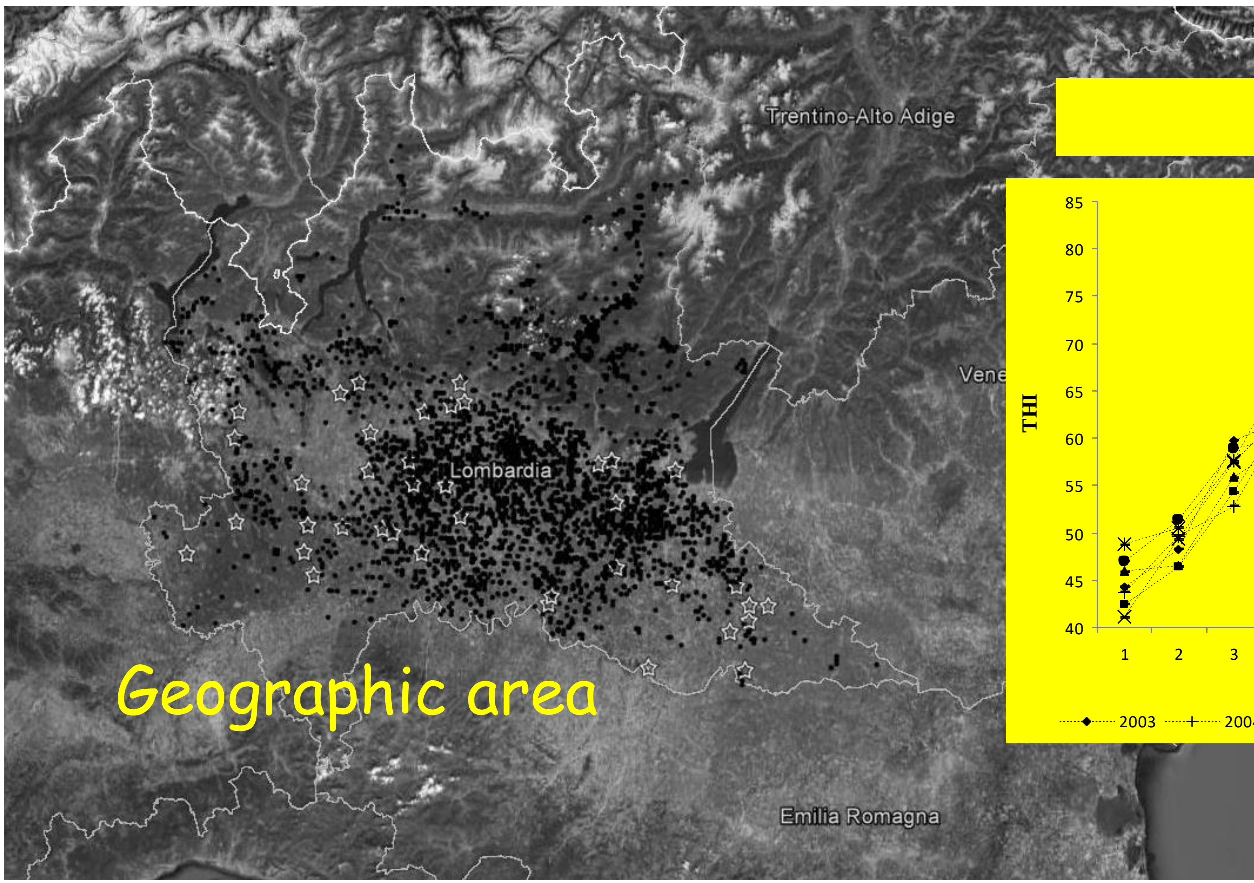
Animal (2014), **8:4**, pp 667–674
doi:10.1017/S1751731114000032

animal

Seasonal variations in the composition of Holstein cow's milk and temperature–humidity index relationship

L. Bertocchi[1], A. Vitali[2], N. Lacetera[2], A. Nardone[2], G. Varisco[1] and U. Bernabucci[2†]

[1]Istituto Zooprofilattico Sperimentale, Lombardia ed Emilia Romagna, Brescia, Italy; [2]Dipartimento di Scienze e Tecnologie per l'Agricoltura, le Foreste, la Natura e l'Energia (DAFNE), Università degli Studi della Tuscia, Viterbo, Italy



Changes of THI

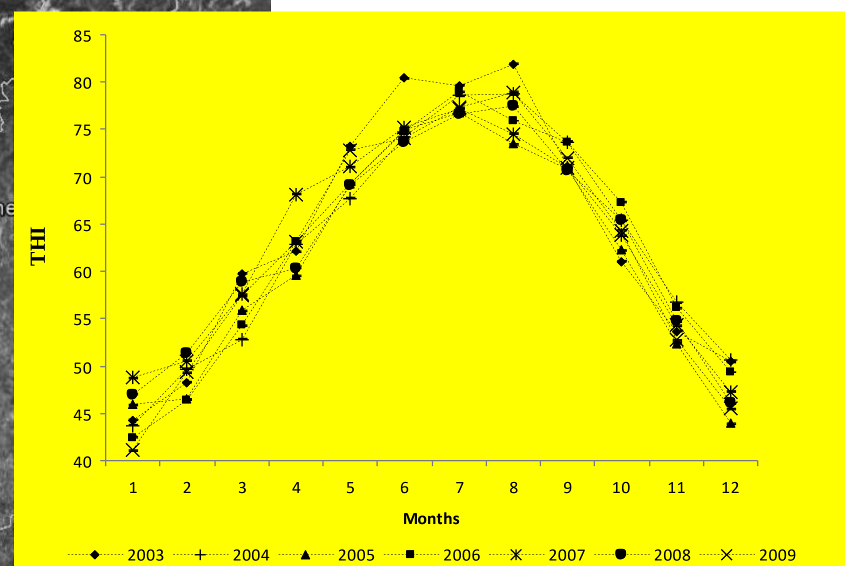


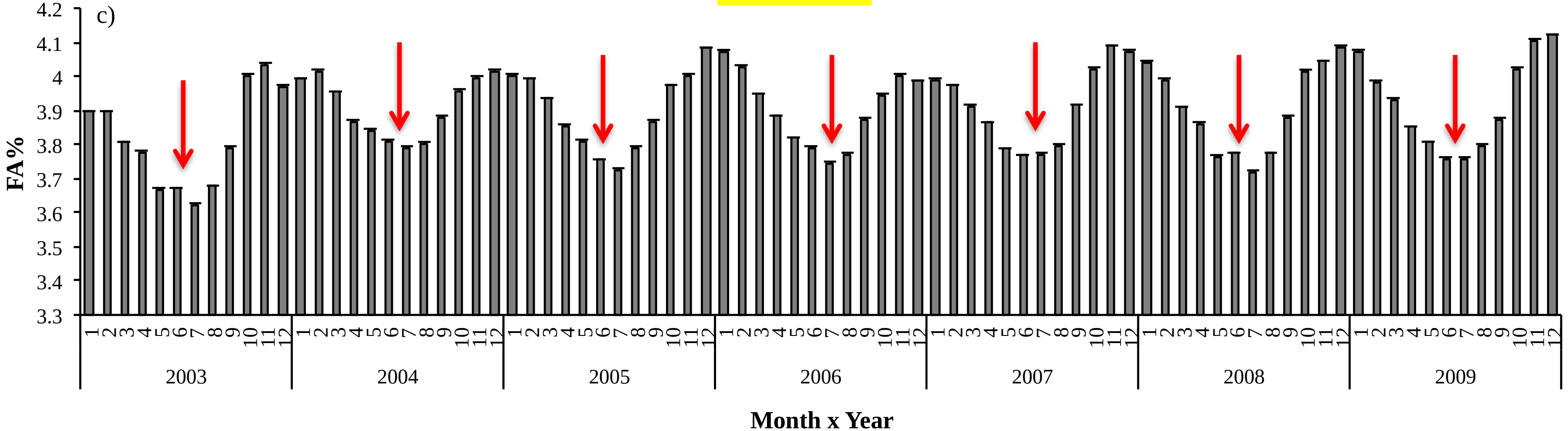
Table 1 *Descriptive statistics of the studies*

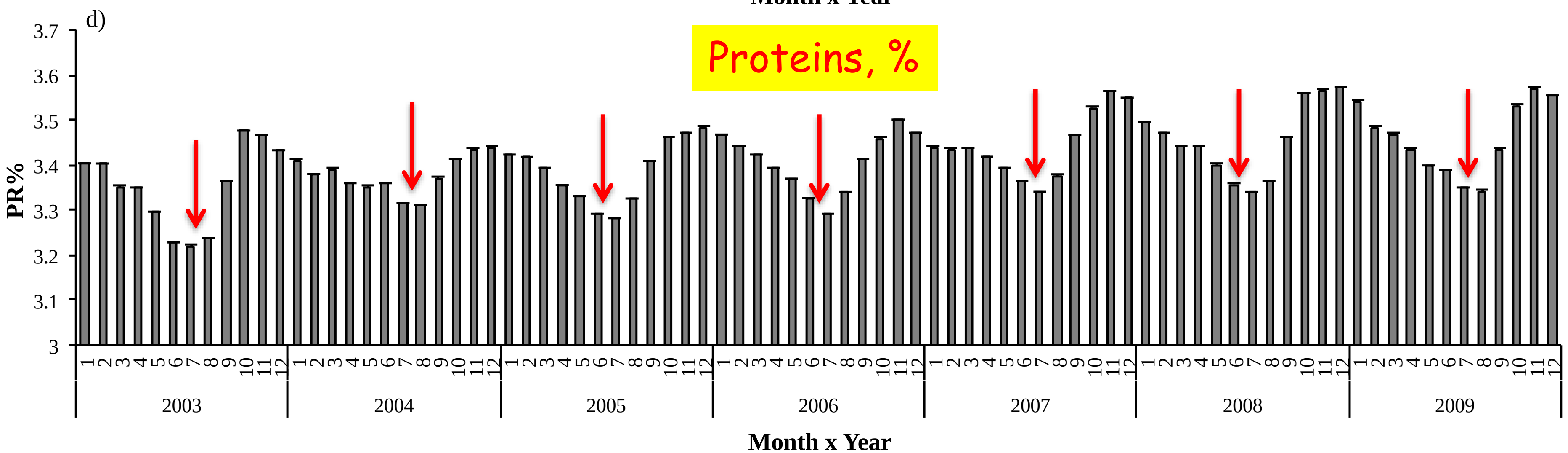
Study period (7 years)	2003 to 2009
Geographical area	North Italy
Area	Po valley
Region	Lombardy
Annual, seasonal and monthly pattern study	
Number of dairy farms	3727
Milk characteristic records	656 064
Number of lactating cows	365 246
THI–milk quality relationship study	
Number of dairy farms	3328
Milk characteristic records	508 613
Number of lactating cows	316 160
Number of weather stations consulted	40
Weather station-farm distance (mean ± s.d.), km	10.92 ± 6.01

THI = temperature–humidity index.

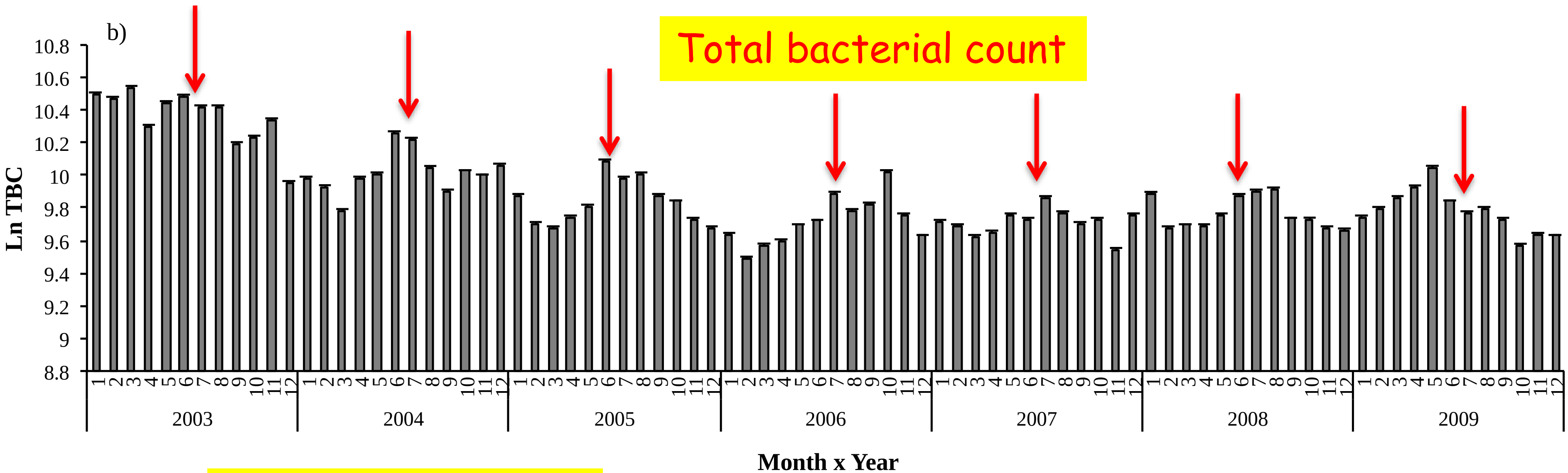
Month x Year: fat and proteins, %

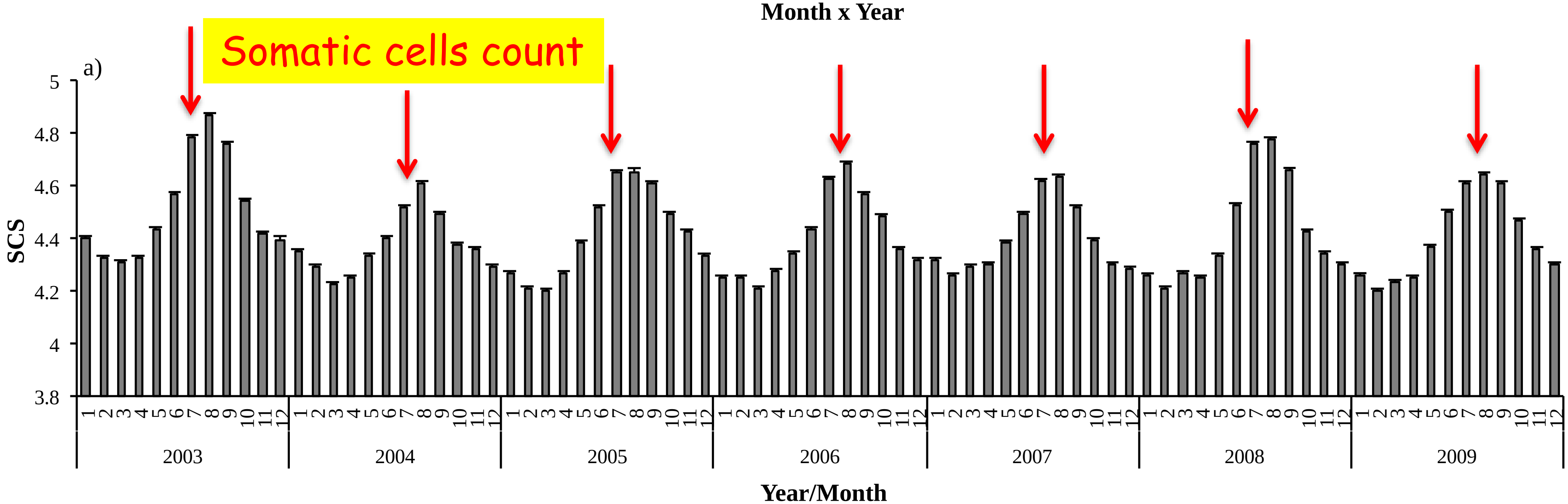
Fat, %



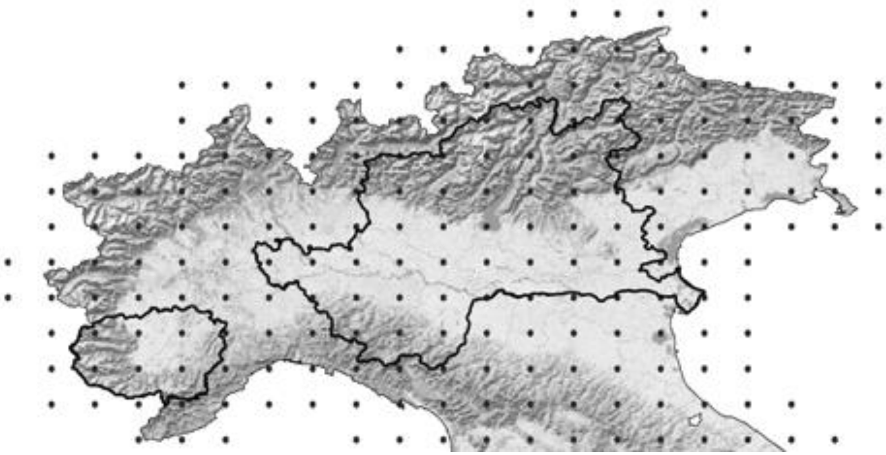


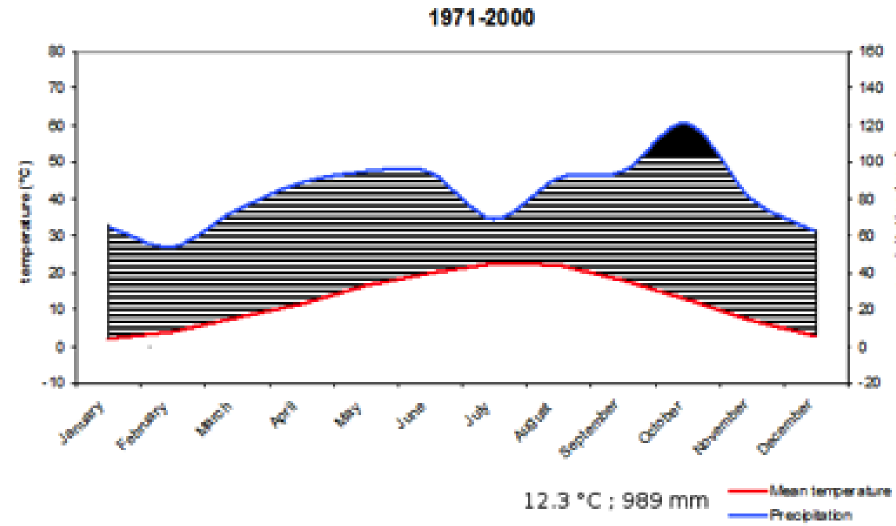
Month x Year: TBC e SCC

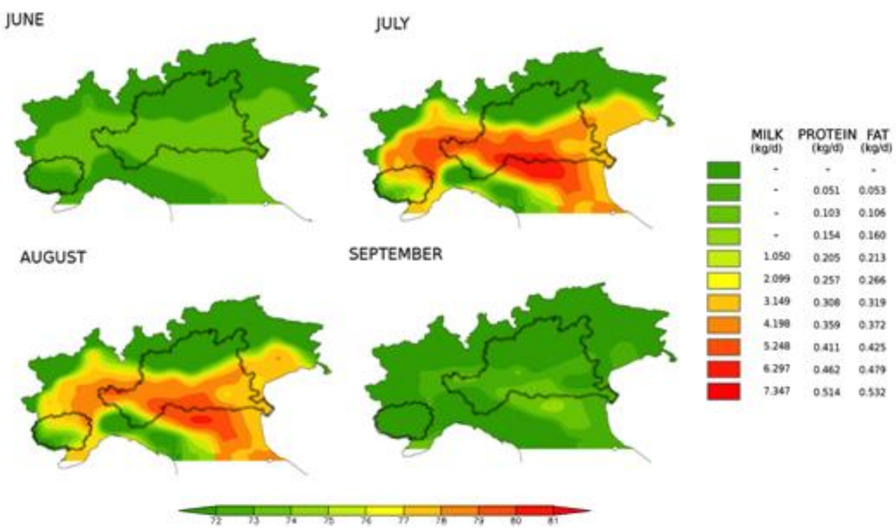


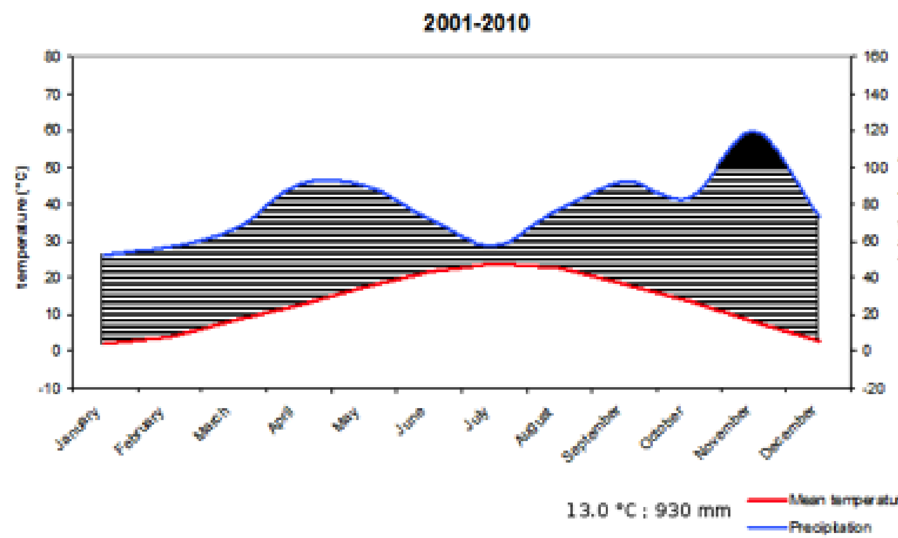


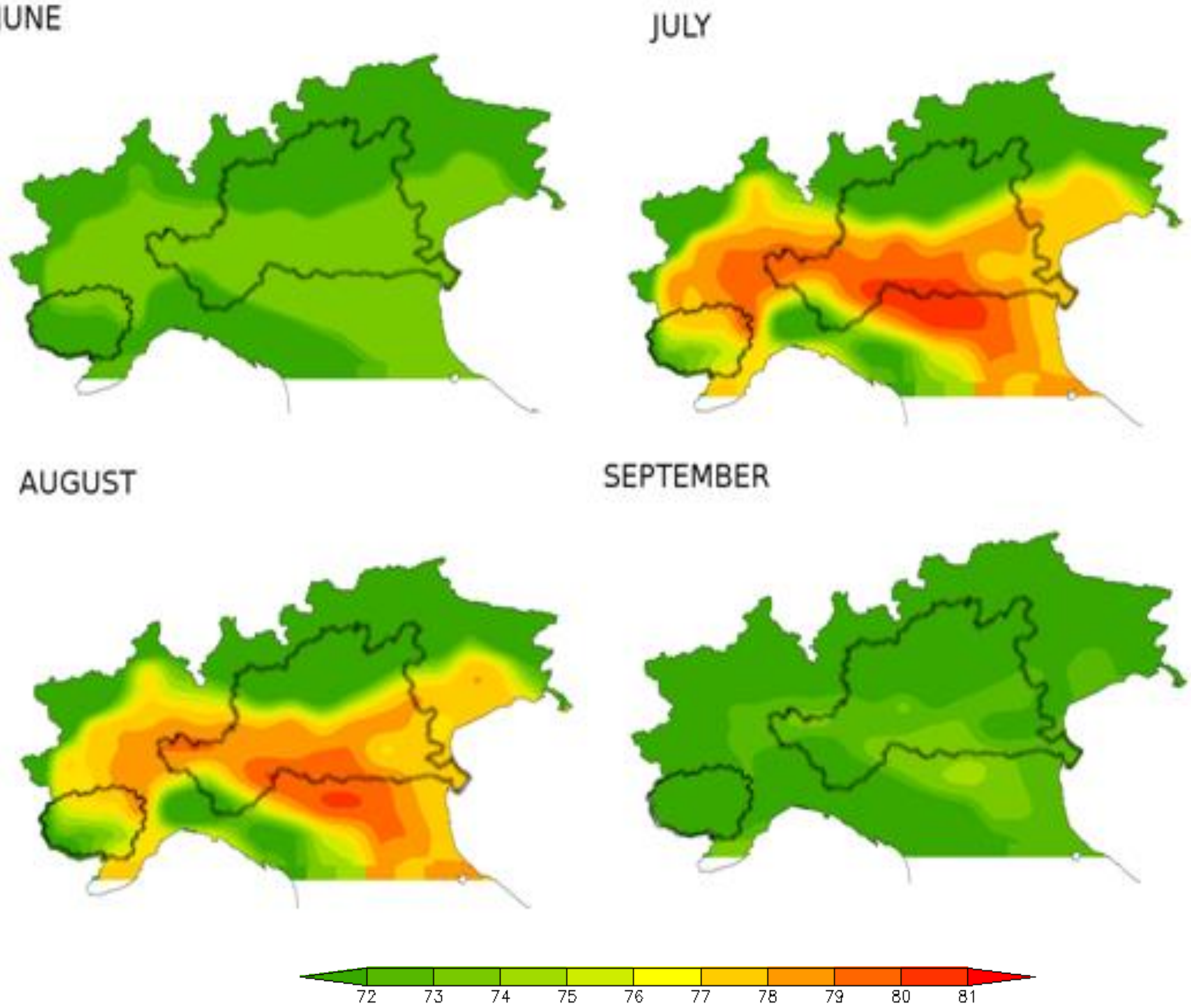
Caratterizzazione del clima della zona di produzione del Grana Padano
Progetto FILIGRANA







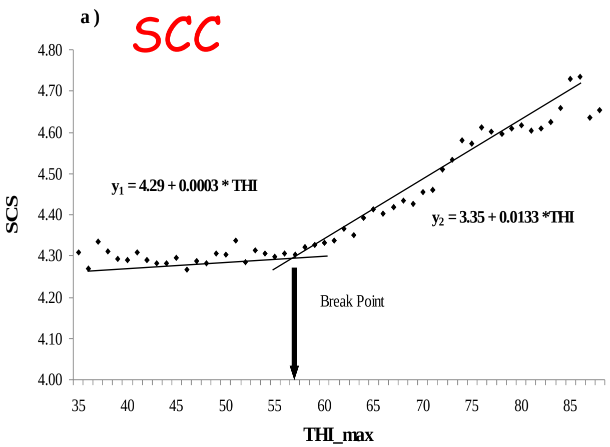




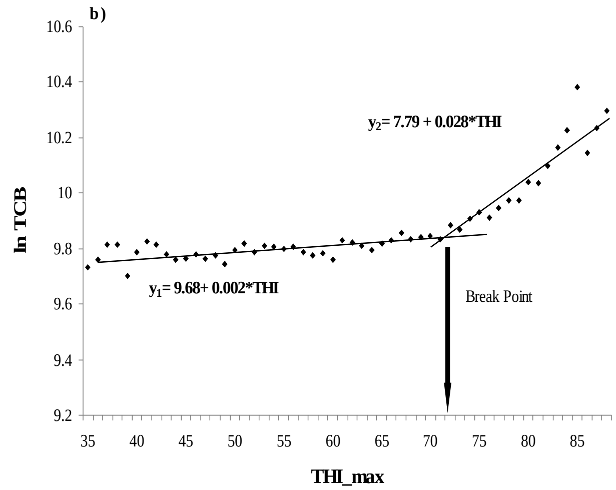
	MILK (kg/d)	PROTEIN (kg/d)	FAT (kg/d)
	-	-	-
	-	0.051	0.053
	-	0.103	0.106
	-	0.154	0.160
	1.050	0.205	0.213
	2.099	0.257	0.266
	3.149	0.308	0.319
	4.198	0.359	0.372
	5.248	0.411	0.425
	6.297	0.462	0.479
	7.347	0.514	0.532

Relationships between THI and Milk characteristics

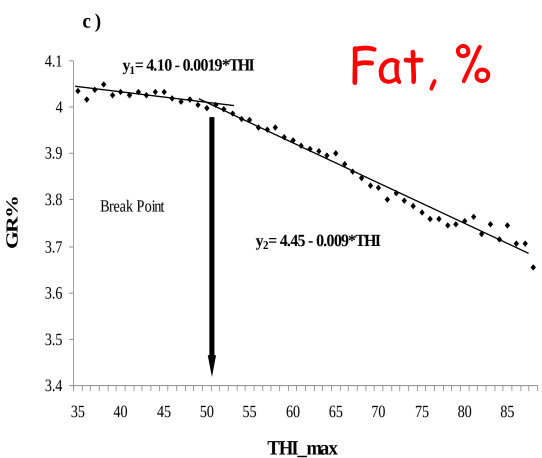
SCC



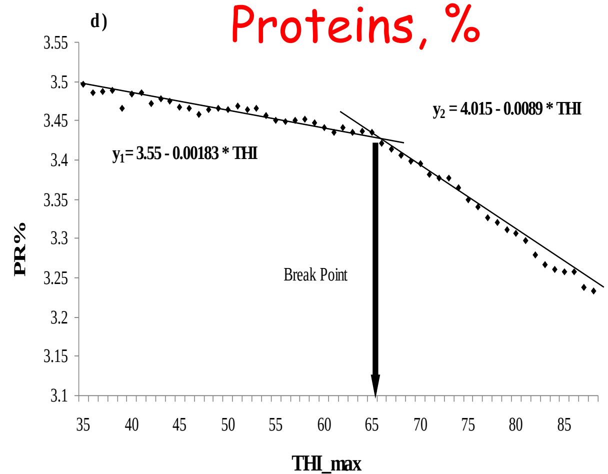
TBC



Fat, %



Proteins, %



Break points:

57.3 THI for (a) SCC;

72.8 THI for (b) TBC;

50.2 THI for (c) Fat %;

65.2 THI for (d) Pr %.

J. Dairy Sci. 98:1815–1827
http://dx.doi.org/10.3168/jds.2014-8788

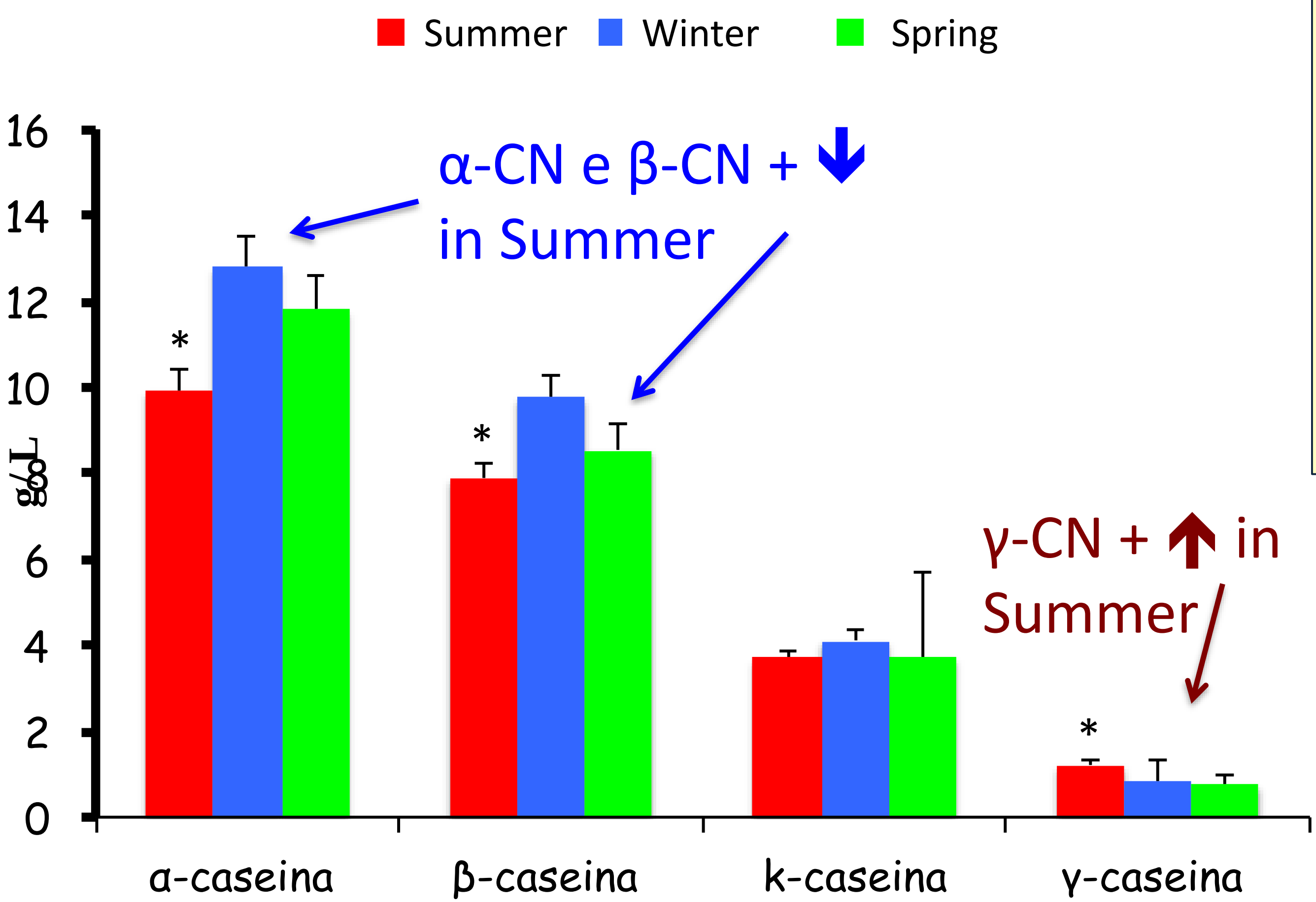
Effect of summer season on milk protein fractions in Holstein cows

U. Bernabucci,*[1] L. Basiricò,* P. Morera,* D. Dipasquale,* A. Vitali,* F. Piccioli Cappelli,† and L. Calamari†
*Dipartimento di scienze e tecnologie per l'Agricoltura, le Foreste, la Natura e l'Energia (DAFNE), Università degli Studi della Tuscia, via S. Camillo De Lellis, s.n.c, 01100 Viterbo, Italy
†Istituto di Zootecnica, Università Cattolica del Sacro Cuore, Via Emilia Parmense, 84, 29122 Piacenza, Italy

Dairy cows, same farm, two types of barns with different characteristics.
At least 4 data-loggers (t°, UR) in each barn.

Barns

Casein fractions



Total casein, %:

Summer 2,27
Winter 2,75
Spring 2,75

% Caseins:

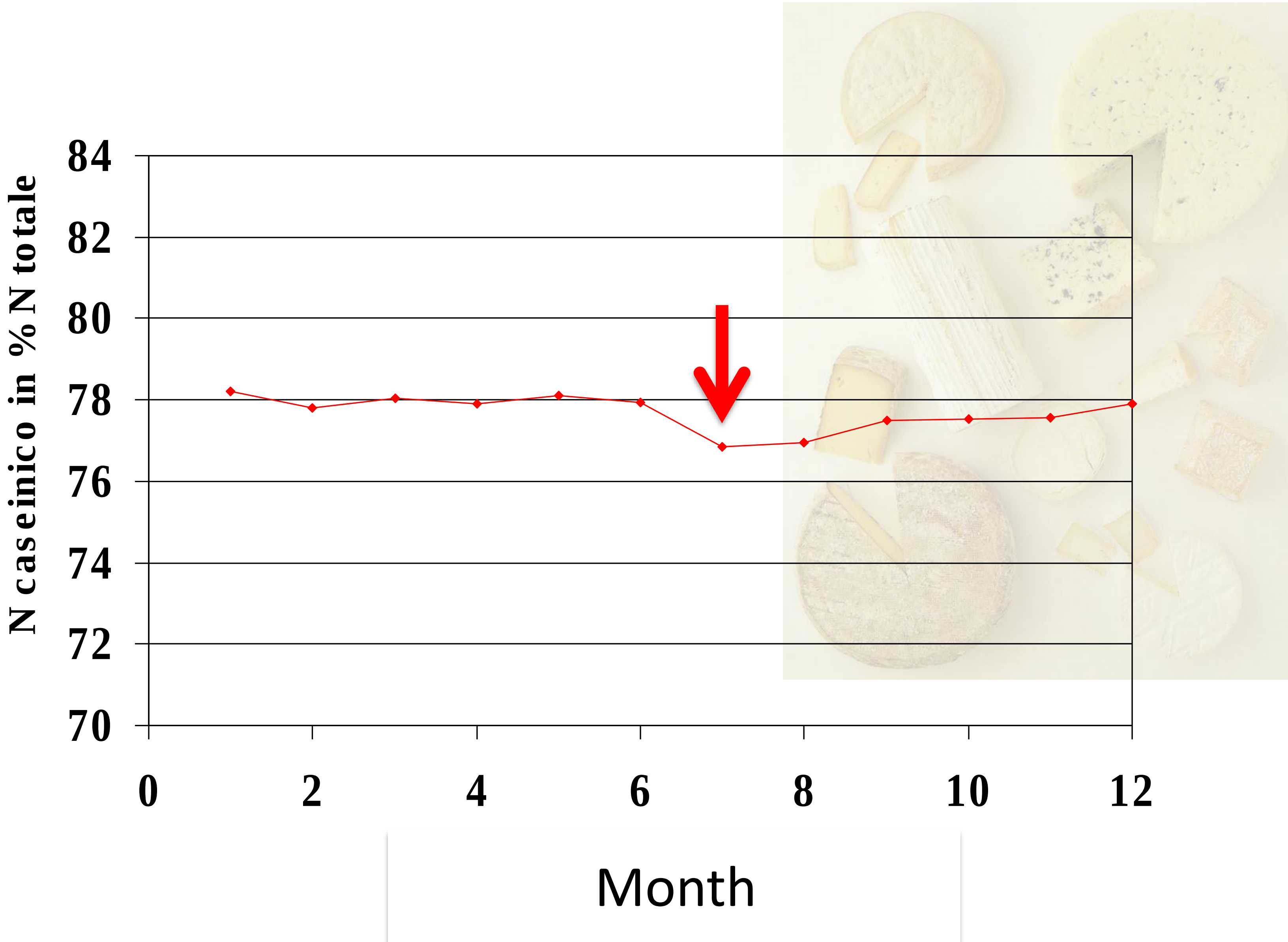
Summer 74,3
Winter 76,7
Spring 76,6

Milk protein fractions (%) in summer (SU) and spring (SP)

	α_s-CN	β-CN	k-CN	α-La	β-LG	spr
SU	1.12^A	0.79^A	0.27	0.16	0.38	0.29^B
SP	1.36^B	0.97^B	0.25	0.17	0.38	0.18^A

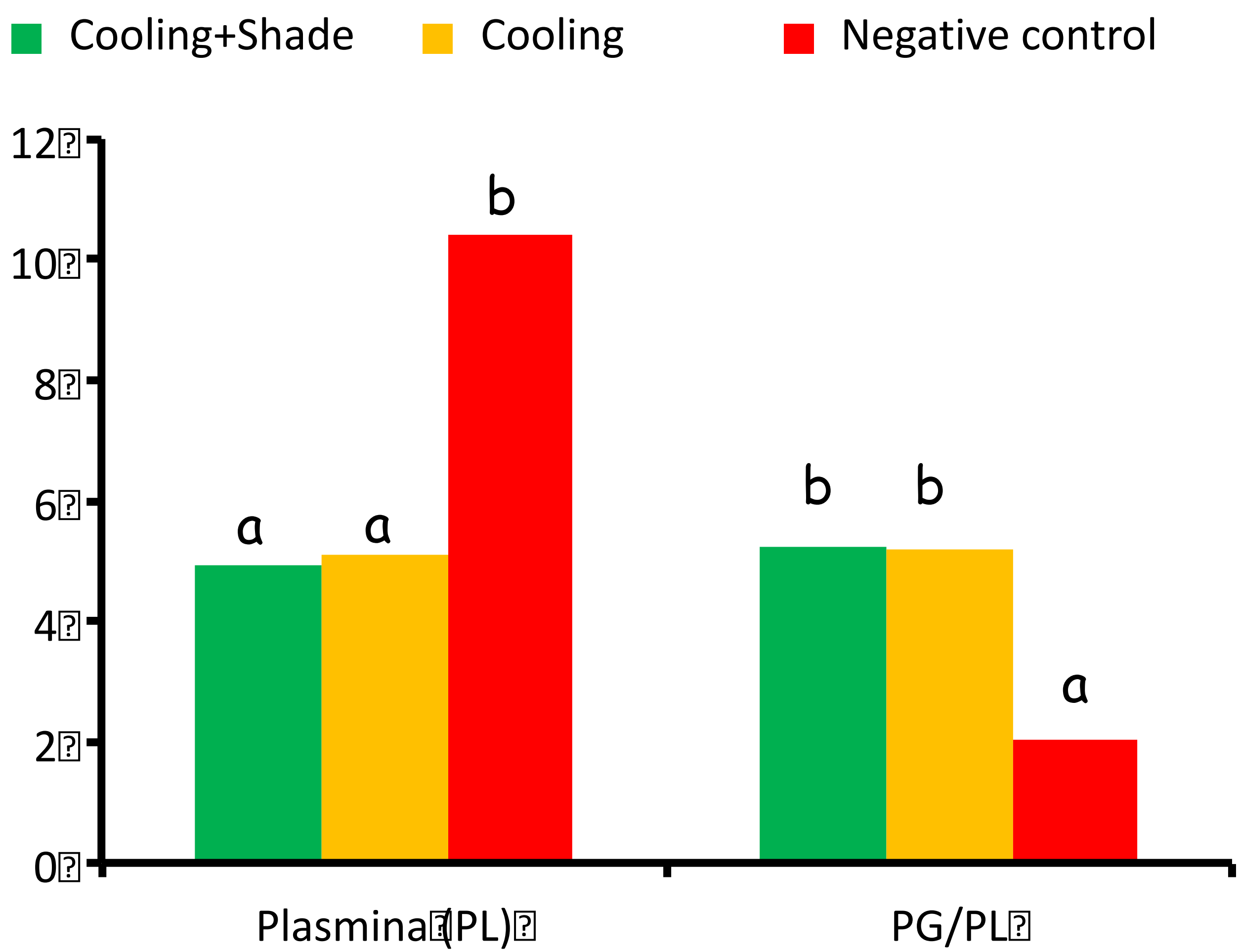
A,B = P < 0.01

(Bernabucci et al., 2002)



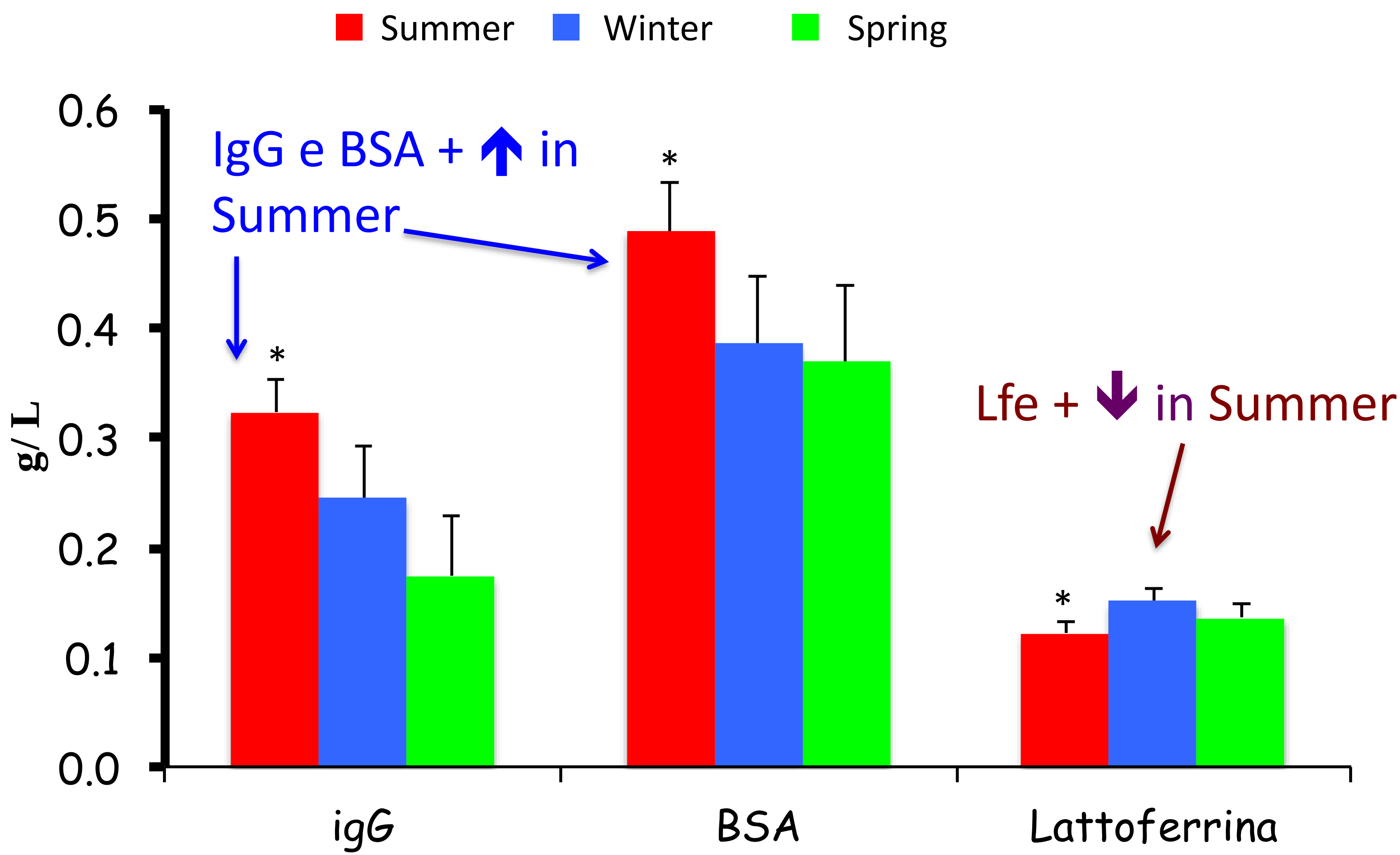
(Summer et al., 1998)

Heat stress effects on milk plasmin activity

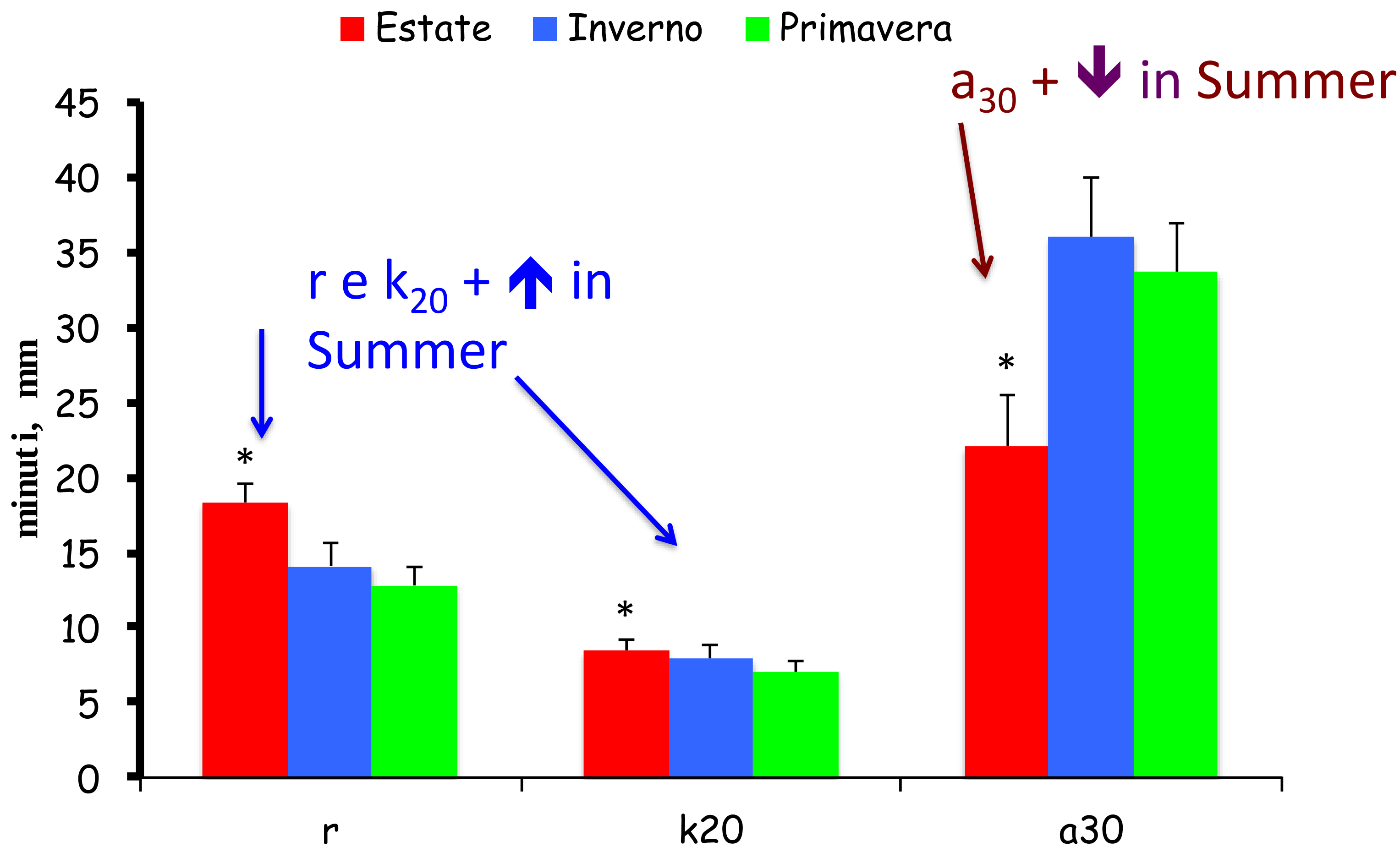


(Silanikove et al., 2009)

Milk serum proteins

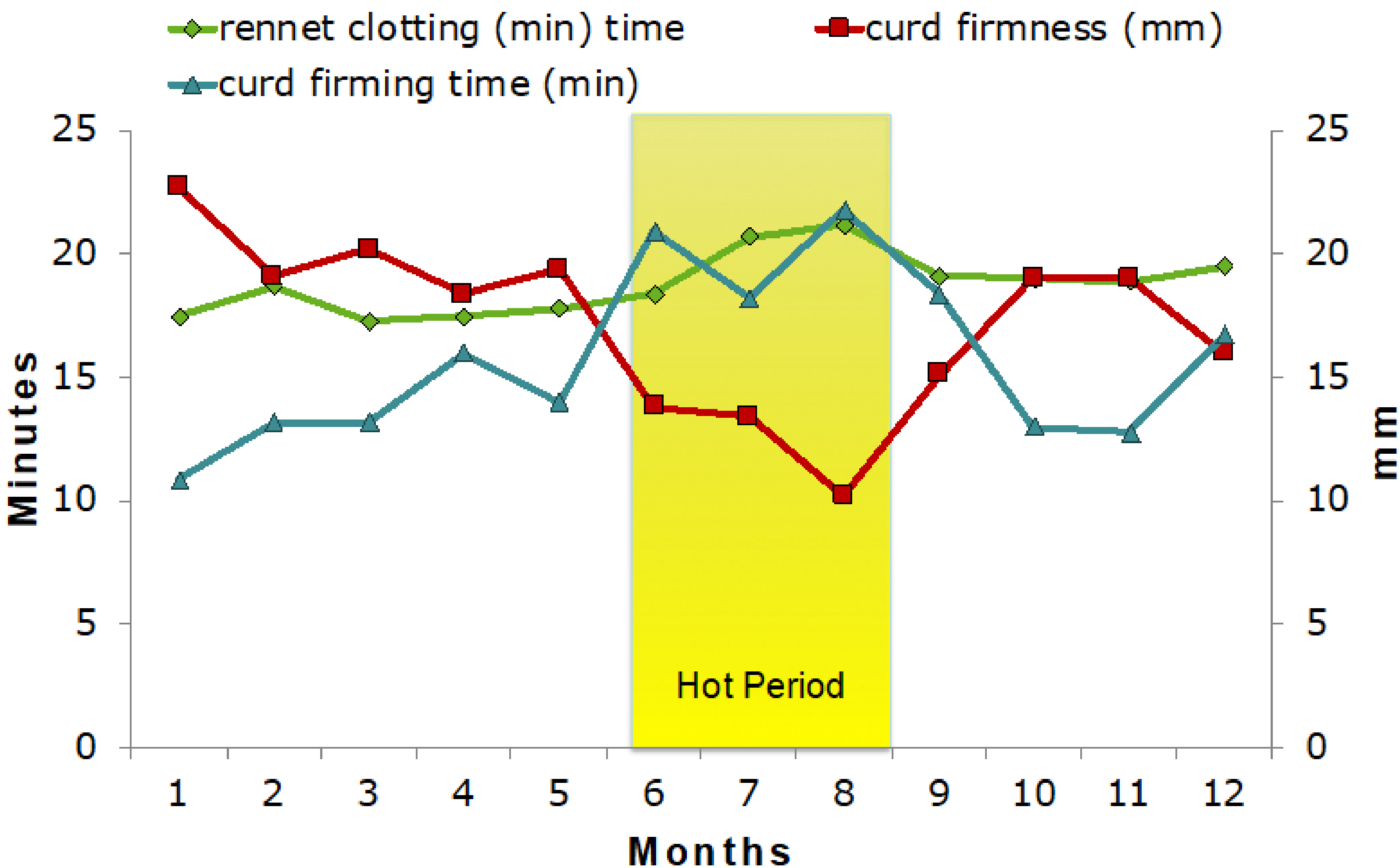


Rennet coagulation time (r, min), curd firming rate (k_{20}, min) and curd firmness after 30 minutes (a_{30}, mm)

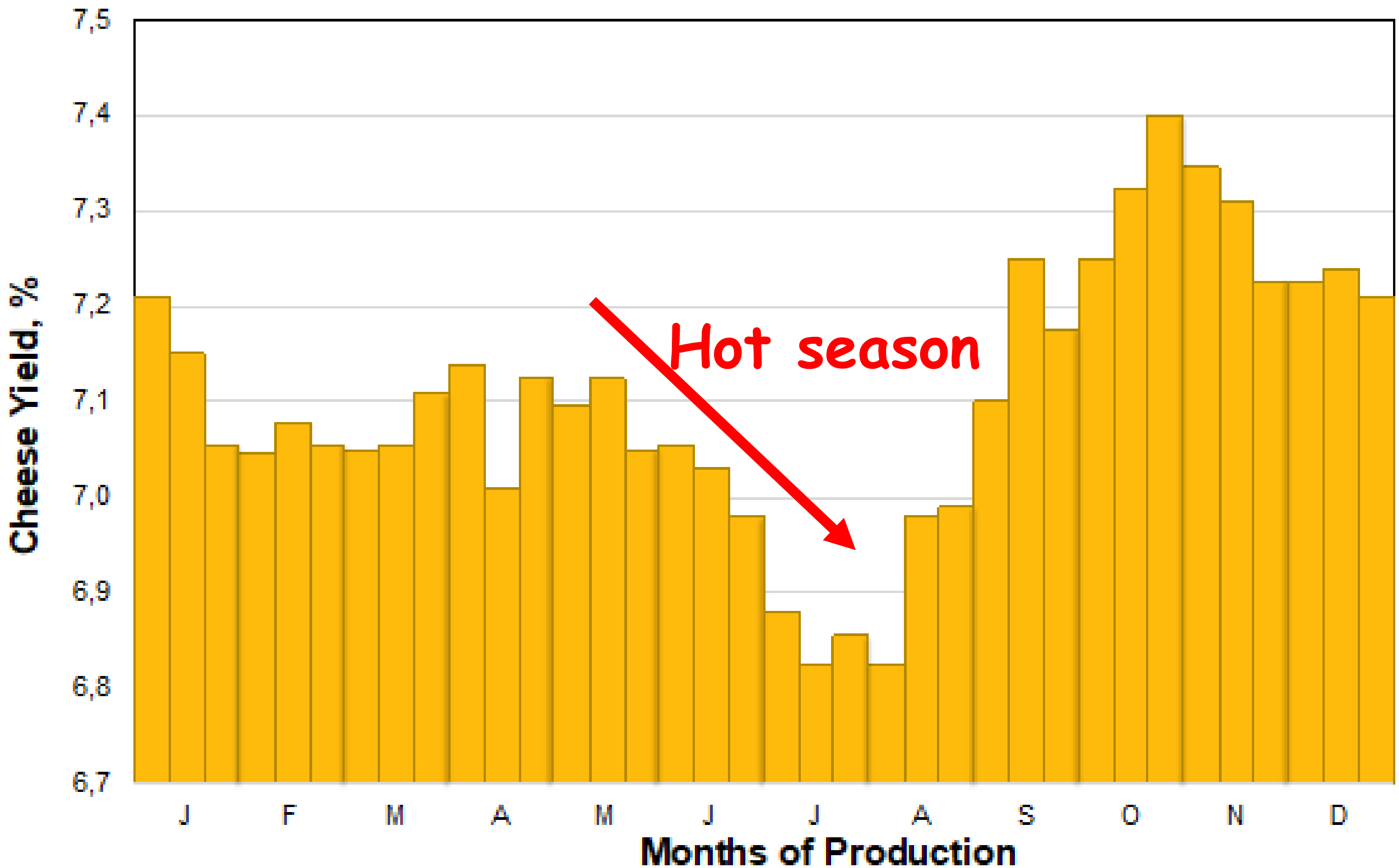


Università degli Studi della Tuscia
Dafne
Dipartimento di scienze e tecnologie per l'Agricoltura, le Foreste, la Natura e l'Energia

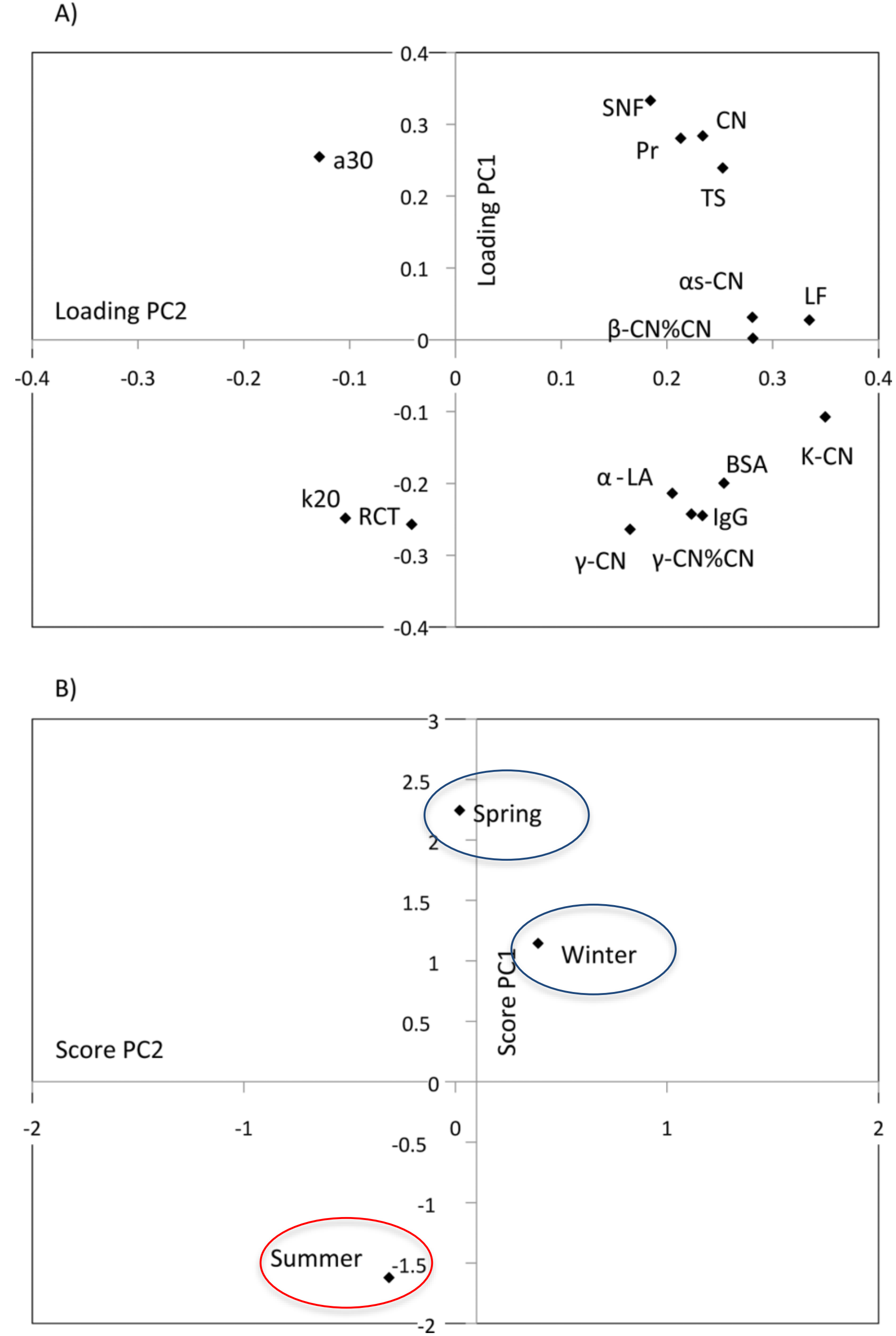
Months of production and Rennet Coagulation properties of the milk (Summer et al, 1999)..



Month of production and <u>Grana Padano cheese</u> yield (%) (Mariani et al, 1995).



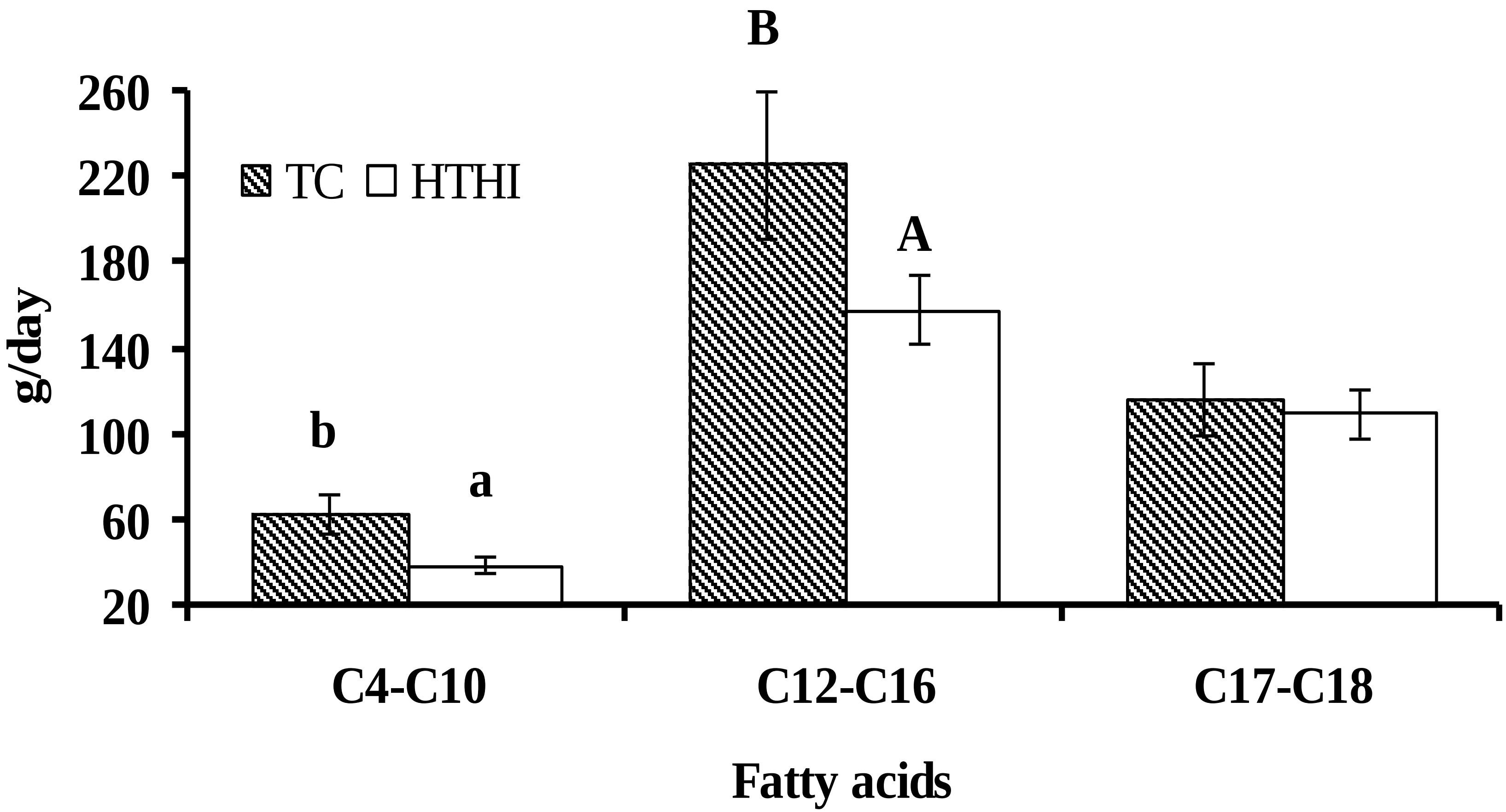
Principal component analysis



RCT,
k20,
γ-CN,
α-lattoalbumina,
IgG
sieroalbumine (BSA).

Figure 3. (A) Loading plot of the first 2 principal components (PC1 and PC2). RCT = rennet coagulation time; k_{20} = curd firming rate; a_{30} = curd firmness. (B) Score plot of PC-analyzed samples collected through season using PC1 and PC2. The PC1 and PC2 accounted for 41.4% of the observed variation in the data.

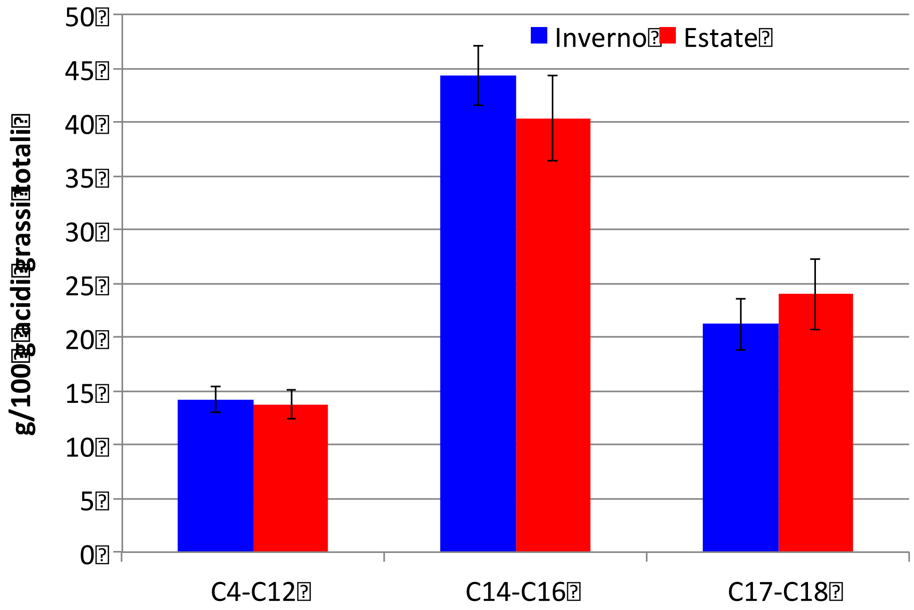
Milk fat composition



a,b = P < 0.05
A,B = P < 0.01

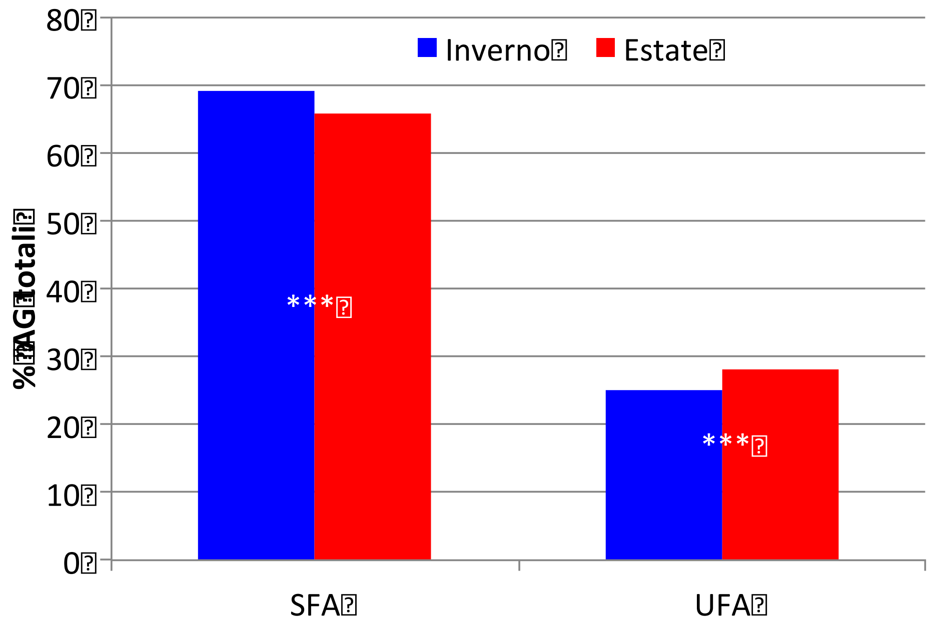
(Ronchi et al. 1995)

Milk fat composition



(Rutten et al., 2009)

Grazing effect during summer



(Duchemin et al., 2013)

Adaptation

- **Structural interventions**: orientation, isolation and reflectance; shading; ventilation with or without water (cooling).

- **Management**: nutrition, availability of water (crops and breeding), reproduction, control and surveillance of diseases (crops and breeding), genetic selection (crops and breeding).

Outlines

1. Housing: cooling systems
2. Feeding
3. Genetics

Housing : cooling

In modern dairy facilities it is essential to minimize variation in in the cow's core body temperature during period of heat stress to maximize milk production and reproductive performances.

Strategy for reducing the negative effects of heat stress is cooling the cows.

There are three ways to accomplish cow cooling:

1. cool the cow,
2. cool the air,
3. or a combination of both.

Housing: cooling

Considering the structure of the free-barn different zones must be cooled:

1. Feed-line cooling
2. Holding-pen cooling
3. Parlor exit cooling

Several systems are available for cooling cows the choice of one or another is dependent of the climate characteristics of the area

Sprinkler and fan cooling systems

Evaporative cooling systems (Korral Kool)

Shade and FlipFan-Shade cooling systems

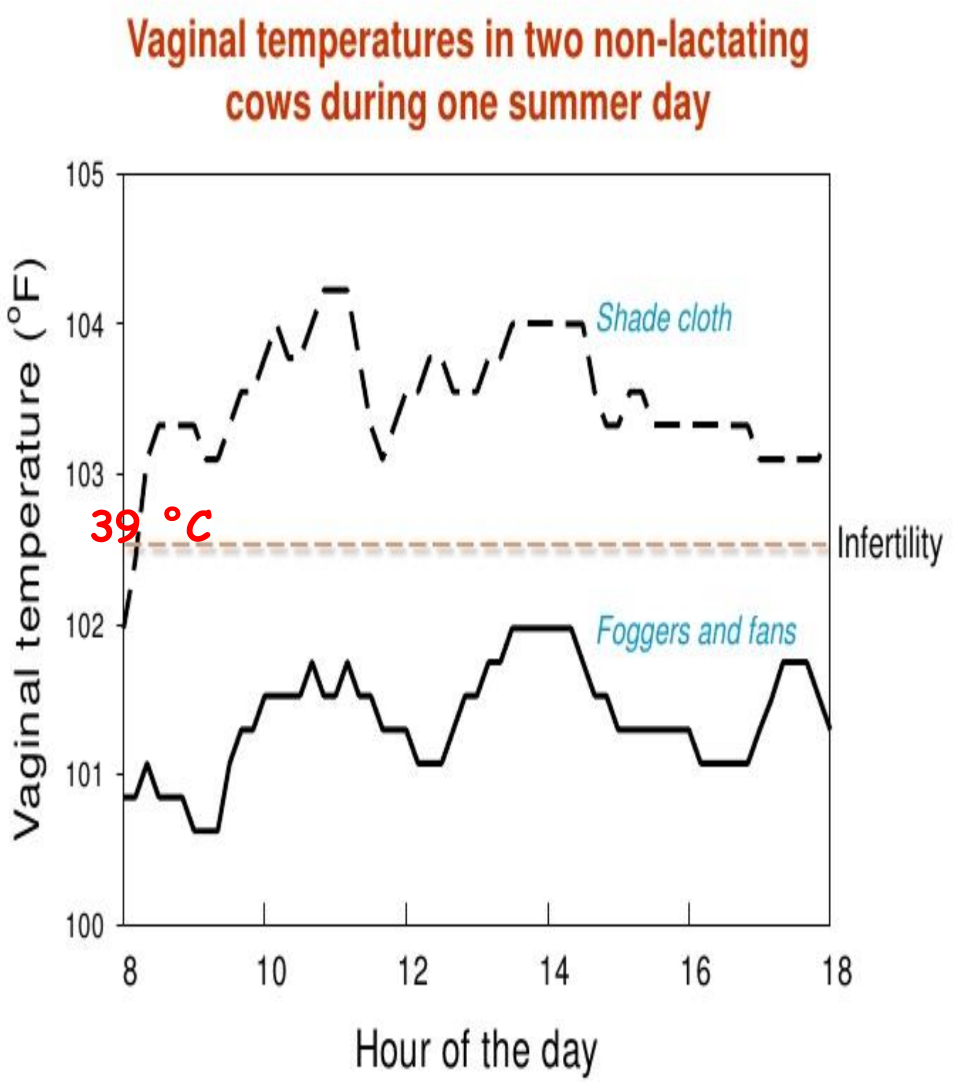
Cooling protocol

- **Intensive cooling**: started in April 2016 for lactating cows and close-up dry cows (from 15 days before calving): **Fans and sprinklers**
- Lactating cows were cooled **4** times per day (2 times before milking, 2 times between milking) for a total of **6** h/d, Fan speed = **3 meters\sec; wetting cows** for **30/50 sec every** 5 min for a total of 1 h and 30 min per treatment.
- This routine was repeated every 4 hours (in the day-time).
- Lactating cows were cooled in **holding pen + feeding strip**
- N° 2 workers are needed to manage the cows

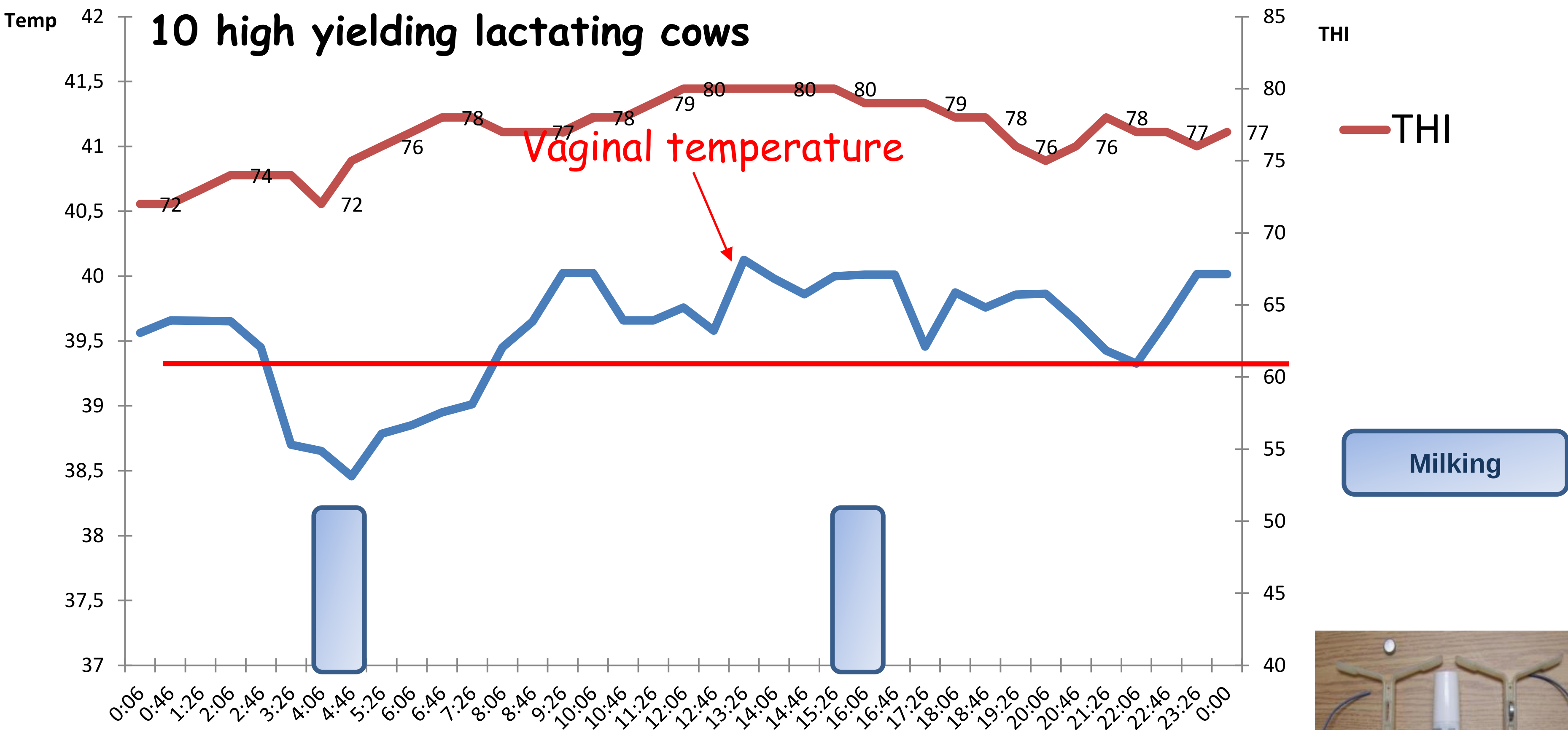
Cooling in holding pen

Cooling in feeding strip

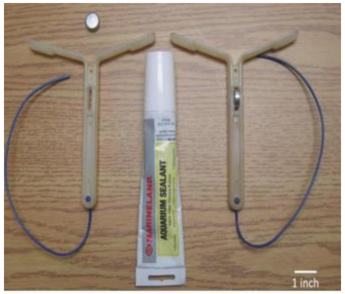
Vaginal temperature and infertility



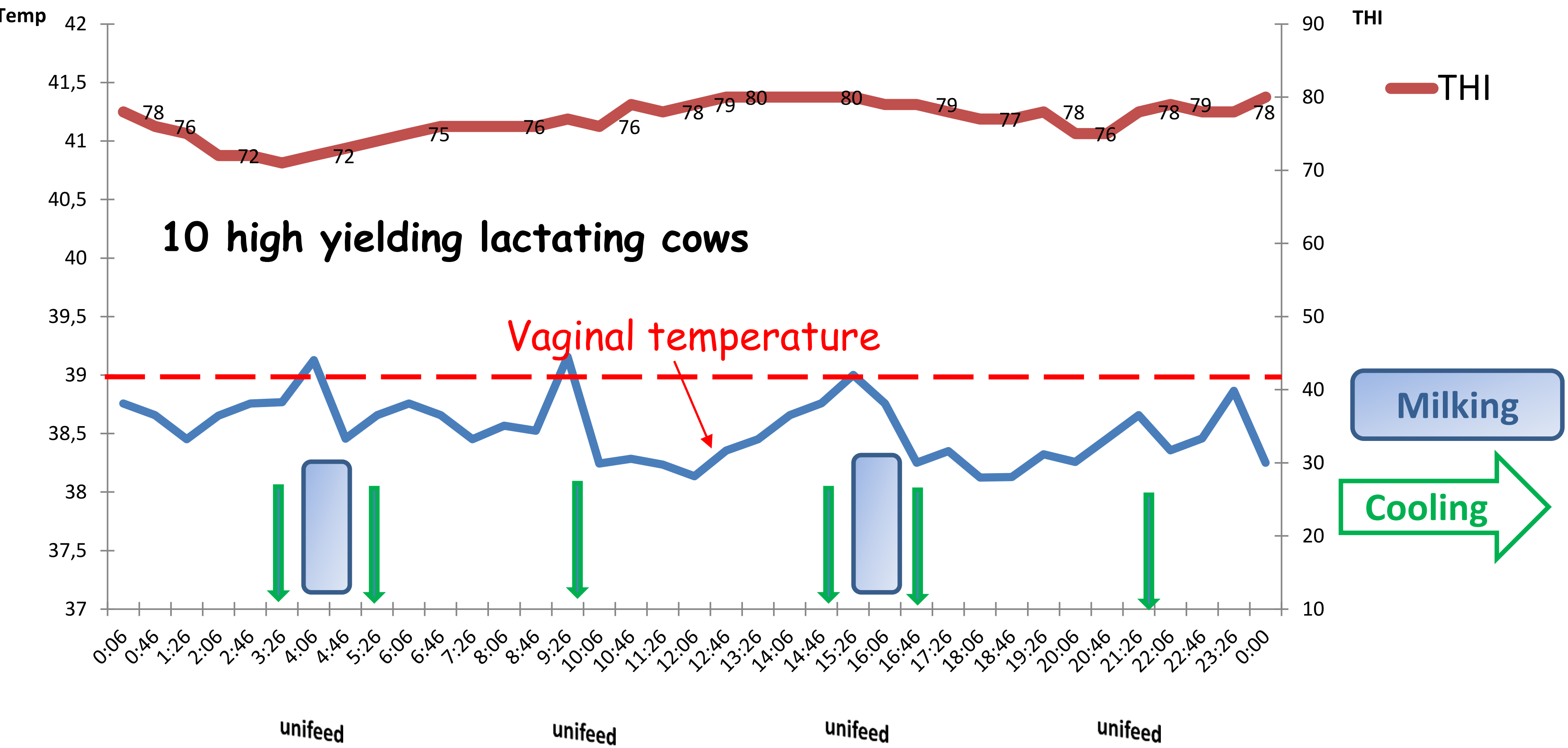
Vaginal temperature in cows treated with moderate cooling



Vaginal temperature measured using wireless active intravaginal device



Vaginal temperature in cows treated with Maccarese intensive cooling protocol

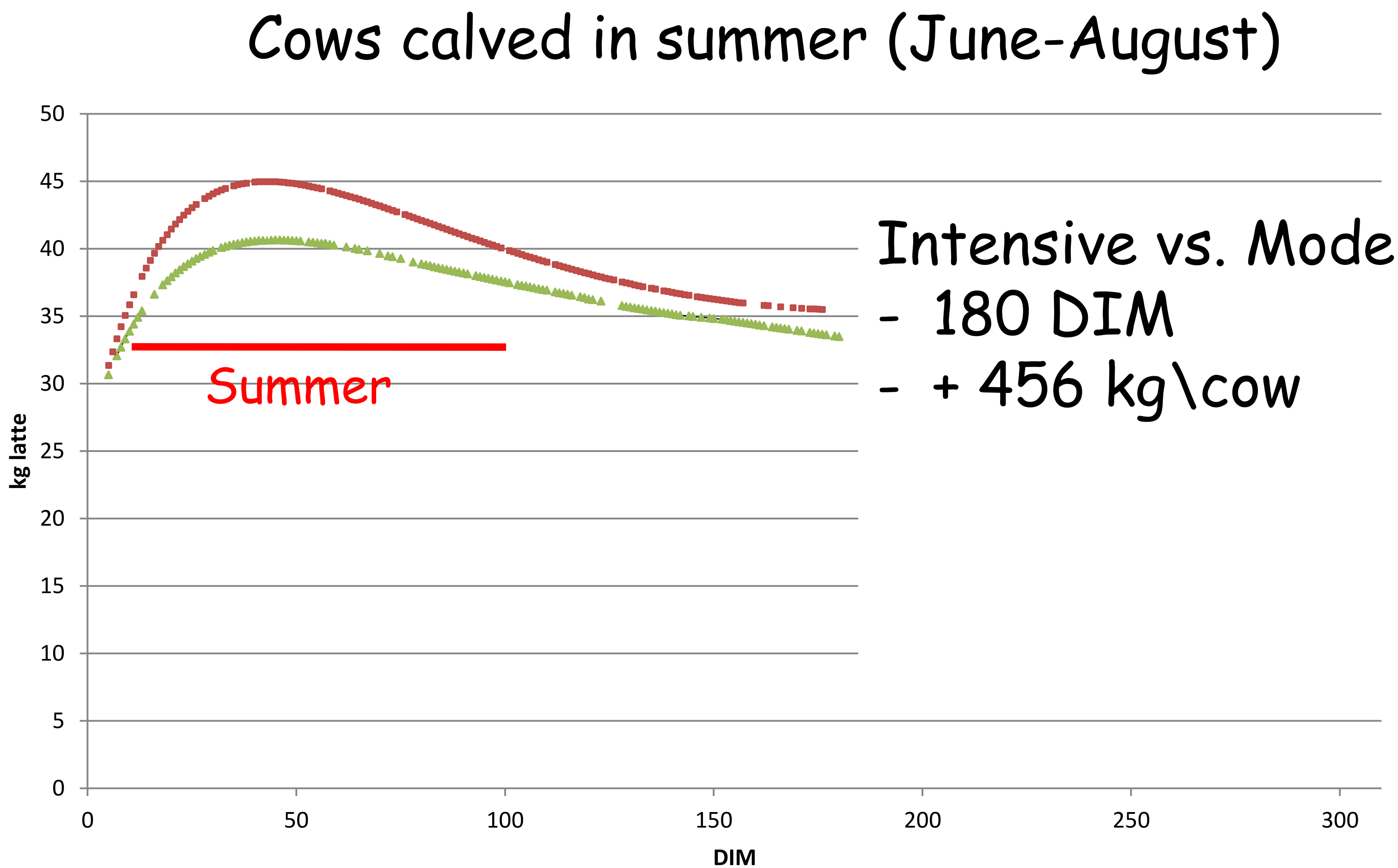


Results: Moderate vs. Maccarese cooling protocol

	Conception rate Moderate	Conception rate Intensive	Improvement (%)
Primiparous (July-September)	17.0%	34.3%	+ 17.3
Multiparous (July-September)	18.7%	31.6%	+12.9

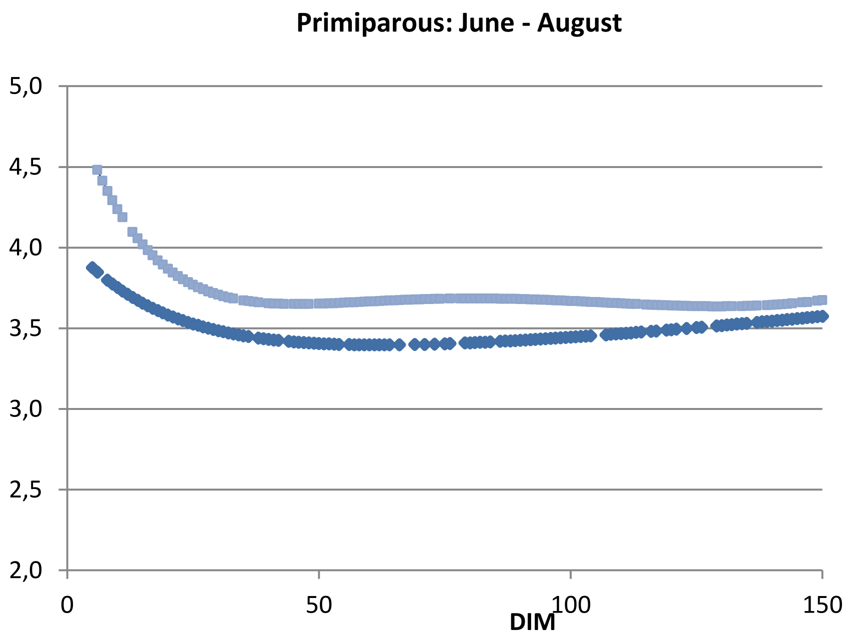
	Pregnancy rate Moderate	Pregnancy rate Intensive	Improvement (%)
Primiparous (July-September)	13%	24%	+11
Pregancy rate multiparous (July-September)	13.6%	23%	+9.4

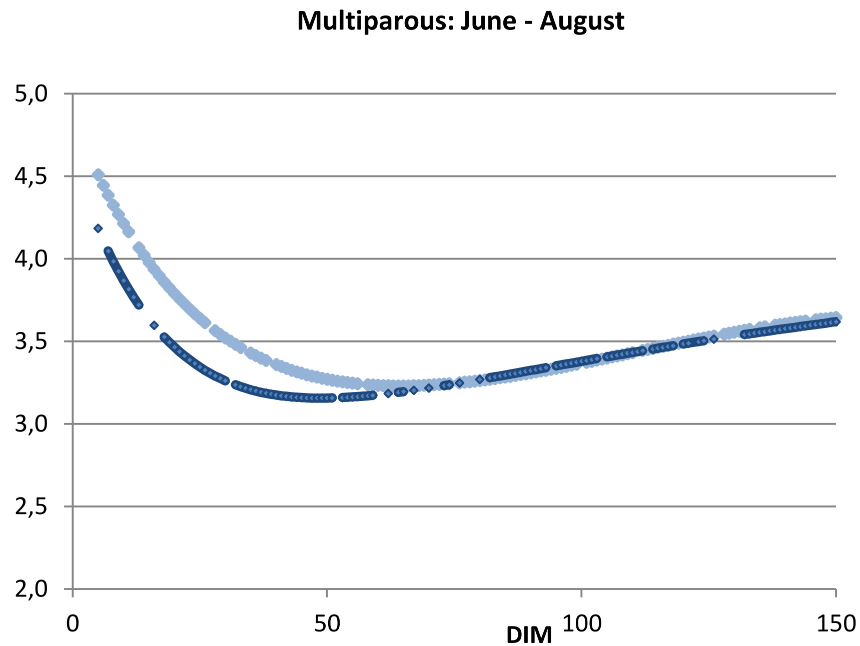
Effect of Maccarese protocol on milk yield



Intensive vs. Moderate:
- 180 DIM
- + 456 kg\cow

Greater milk fat content





	Moderate	Intensive	Difference (Kg)	Difference (%)
Milk yeld (kg/cow)	10,040	10,880	+ 840	+ 8%
Fat (kg/cow)	372	412	+ 40	+ 7.5%

Feeding

1) Adjust rations to increase energy, protein and nutrient intake and contemporarily maintaining animal health when animals are exposed to heat stress conditions (quality of fiber).

2) Some nutrients are required at higher levels during heat stress (K and Na, vitamins (A, E and C) and microelements (Se, Zn) for example).

3) *Water quality*, temperature and ***availability*** are a must for animals when exposed to hot conditions. Water should be available in holding pens, travel alleys, and near feed bunks and has to be clean.

Effects of vit E and Se on dairy cows performances

Field experience

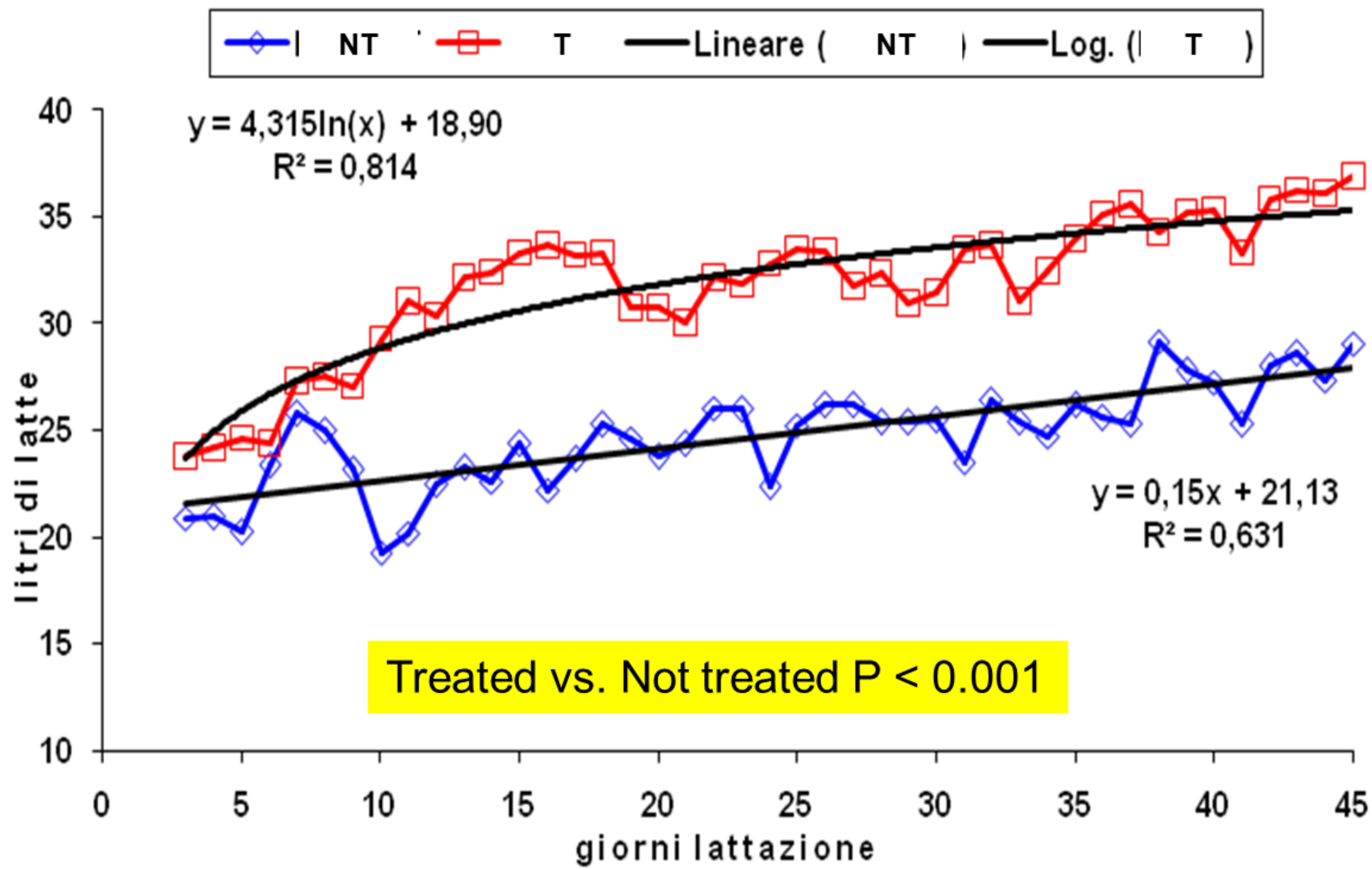
Dairy cattle farm June-August

Dairy cows monitored from -25 to +30 days from calving:

- *10 treated Se*: 5 µg x 100 kg BW
  Vit E: 25 IU x 100 kg BW

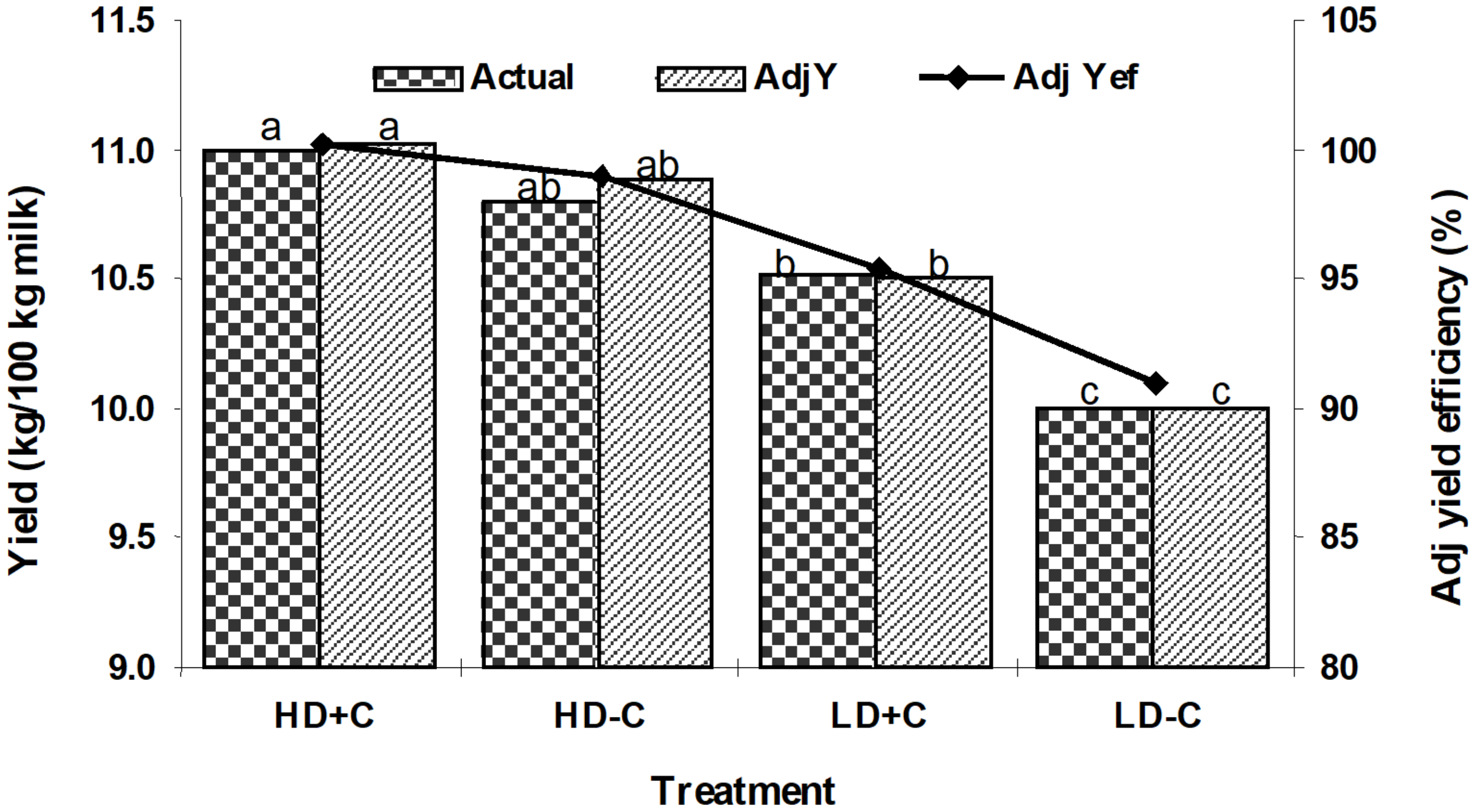
- *10 not treated* (saline solution)

Milk yield



NT
T
Lineare (NT)
Log. (T)
y = 4,315ln(x) + 18,90
R² = 0,814
y = 0,15x + 21,13
R² = 0,631
litri di latte
giorni lattazione
Treated vs. Not treated P < 0.001

Effect of forage quality and cooling on Cheddar cheese yield



Genetic selection for heat tolerance

Can we select high yielding dairy ruminants for thermoregulatory capacities?

Period	years	2001-2007
Test Day Record	N	1,5 milions
Cows (1°, 2° 3° birth)	N	190,000
Herds (H)	N	400
Meteo Stations (MS)	N	35
Maximum Distance (H-MS)	km	5
Climatic data		T. and RH
Calculation at coordinates of the farm (“spatialization”)		THI

Productive detected data

- **Milk** **kg**
- **Proteins** **%**
- **Fat** **%**

J. Dairy Sci. 97:471–486
http://dx.doi.org/10.3168/jds.2013-6611

The effects of heat stress in Italian Holstein dairy cattle

U. Bernabucci,* S. Biffani,† L. Buggiotti,* A. Vitali,* N. Lacetera,* and A. Nardone*[1]
*Dipartimento di scienze e tecnologie per l’Agricoltura, le Foreste, la Natura e l’Energia (DAFNE), Università degli Studi della Tuscia, 01100 Viterbo, Italy
†Associazione Nazionale Allevatori Frisona Italiana (ANAFI), 26100 Cremona, Italy

Estimation

n. days THI effects

day max THI effect

THI breack point

h^2 thermotolerance

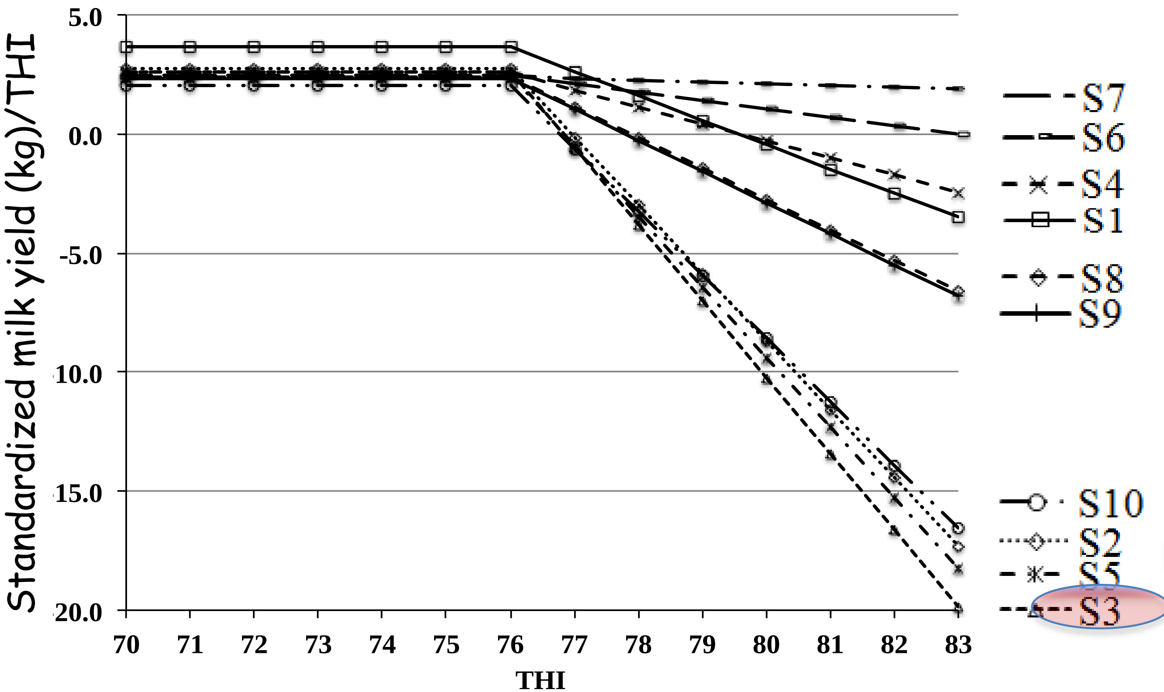
EBV (with and without THI)

Milk yield: ranking of the first 50 Italian Holstein bulls based on EBV calculated with or without considering THI

Sire	RANK EBV	RANK THI
S1	1	1
S2	2	3
S3	3	2
S4	4	5
S5	5	8
S6	6	4
S7	7	6
S8	8	10
S9	9	7
S10	10	9
S11	11	11
S12	12	14
S13	13	13
S14	14	17
S15	15	16
S16	16	23
S17	17	25
S18	18	12
S19	19	27
S20	20	19
S21	21	15
S22	22	30
S23	23	26
S24	24	20
S25	25	18

Sire	RANK EBV	RANK THI
S26	26	21
S27	27	36
S28	28	28
S29	29	22
S30	30	39
S31	31	33
S32	32	29
S33	33	41
S34	34	38
S35	35	42
S36	36	34
S37	37	24
S38	38	37
S39	39	47
S40	40	45
S41	41	35
S42	42	46
S43	43	50
S44	44	82
S45	45	32
S46	46	31
S47	47	48
S48	48	40
S49	49	55
S50	50	59

Prediction of sires' EBV for milk yield as a function of temperature-humidity index (THI) for the first ten ranked bulls



Sire rank within 76 THI	EBV	Sire rank at 83 THI
S1	3.64	4
S2	2.72	8
S3	2.61	10
S4	2.58	3
S5	2.46	9
S6	2.45	2
S7	2.43	1
S8	2.42	5
S9	2.35	6
S10	2.05	7

Genomics

PRINCIPAL COMPONENT and GWAS

J. Dairy Sci. 100:4683–4697
https://doi.org/10.3168/jds.2016-12249

Derivation and genome-wide association study of a principal component-based measure of heat tolerance in dairy cattle

N. P. P. Macciotta,*[1] S. Biffani,† U. Bernabucci,‡ N. Lacetera,‡ A. Vitali,‡ P. Ajmone-Marsan,§ and A. Nardone‡[1]
*Dipartimento di Agraria, Università di Sassari, 07100 Sassari, Italy
†Associazione Italiana Allevatori, 00161 Roma, Italy
‡Dipartimento di Scienze Agrarie e Forestali, Università degli Studi della Tuscia-Viterbo, 01100 Viterbo, Italy
§Istituto di Zootecnica, Università Cattolica del Sacro Cuore, 29122 Piacenza, Italy

N. P. P. Macciotta, S. Biffani, U. Bernabucci, N. Lacetera, A. Vitali, P. Ajmone-Marsan, and A. Nardone.
Derivation and genome-wide association study of a principal component-based measure of heat tolerance in dairy cattle.
Journal of Dairy Science, 2017

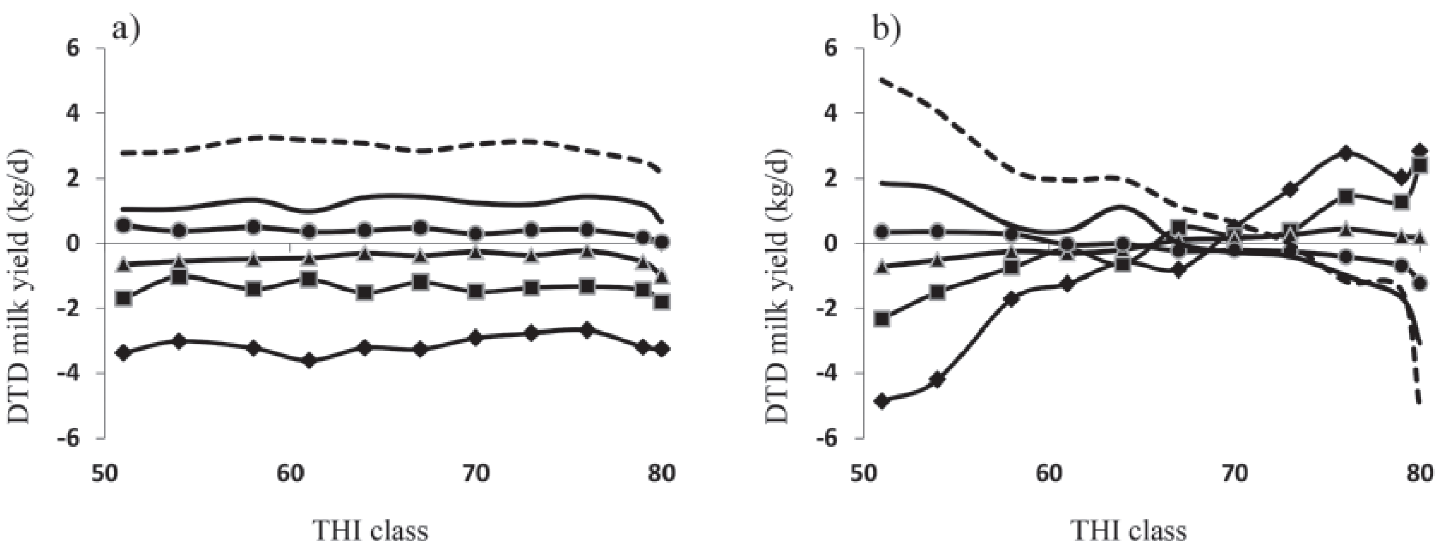


Figure 2. Average curves of daughter trait deviations (DTD) for milk yield of groups of bulls of different level (a) and slope (b) score classes (◆ = <−2; ■ = −2 to −1; ▲ = −1 to 0; ● = 0 to 1; continuous line = 1 to 2; dotted line = >2). Points are plotted for the average DIM on each test day. THI = temperature-humidity index.

SNP Associated with Level and Slope

	Slope (n)	Level (n)	
Milk Yield	2		1) BTA 26≅22,3 Mb. C. gene *BTRC* in cattle: (milk and leg) Folliculogenesis FGF8. Sweating rate 2) BTA 6≅35,5 Mb. C. gene *CCSER1* birth weight (rectal temperature and respiration rate)
Fat %		4	1) BTA 14≅0,6 Mb. (SNP: ARS-BF-GLNGS-4939) associated with milk fat in Holstein (I-USA-C-D) and in Simmental (I) C. gene DGAT1-HSFI 2) C. gene central nervous system, fat composition in cattle, homeostasis, acute heat stress in fish 3) C. gene for SCS in Chinese Holstein 4) C. gene *ZNF34*, fat % in Holstein (China) and Simmental
Protein %	1	1	1) (Slope) BTA5 C. gene *MCAT*, atretic bovine follicles 2) (Level) BTA14
Total	**3**	**5**	

Seasonal trends of curd firmness (mm) of Friesian and Brown herd milk (Malacarne et al, 2005).