Impatto dei cambiamenti climatici sui sistemi zootecnici intensivi ed estensivi

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Impatto dei Cambiamenti Climatici sui Sistemi Zootecnici
Pisa, 17.05.2019

Outline

1. Terms definition:
   - heat stress
   - acclimation/adaptation

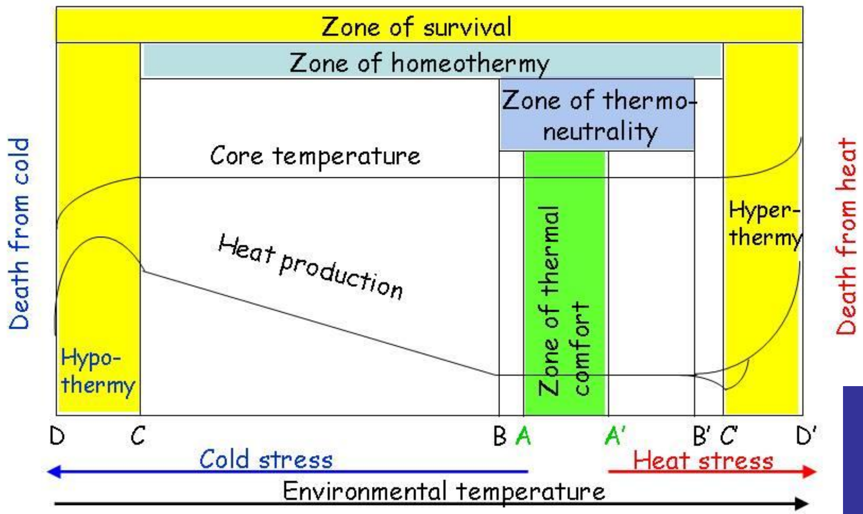
2. Biological consequences of acclimation:
   - Health, Reproduction and Production

3. Livestock production systems and sustainability under climate changes

4. Concluding remarks

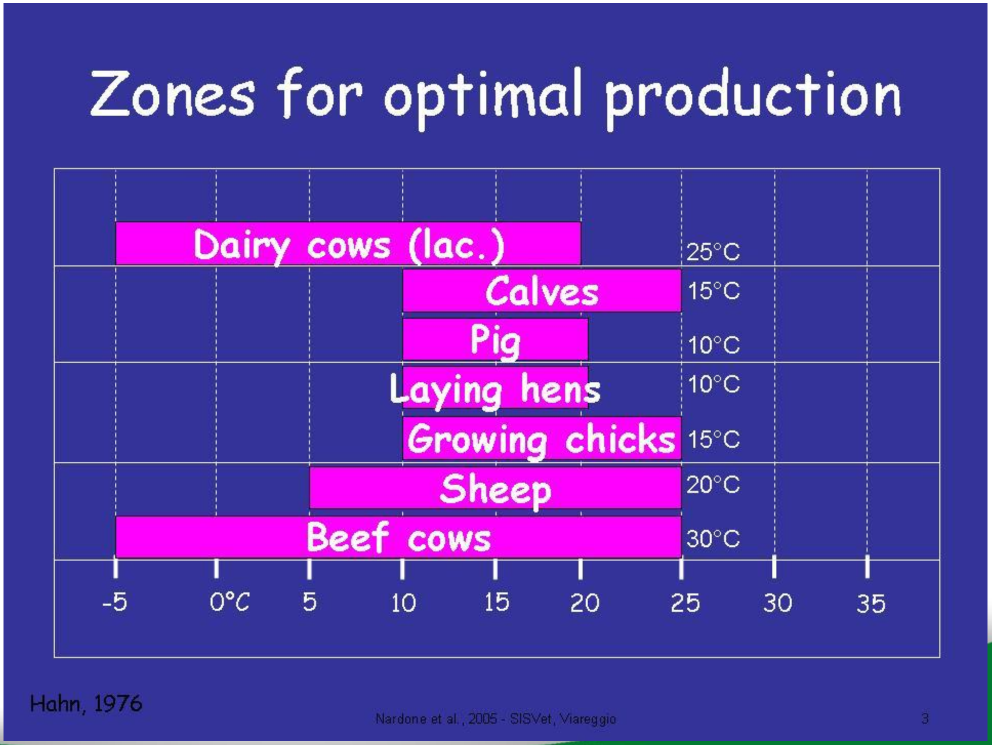
Heat Stress Definition

Lo stress da caldo si ha quando la temperature corporea eccede il il il valore specifico per le normali attività ed è il risultato dell'accumulo di calore (produzione endogena e dall'ambiente) che eccede la capacità di dissipare il calore stesso.



Bianca, 1976

Nardone et al., 2006 - UNASA



Acclimation / Adaptation

International Commission for Thermal Physiology, 2001 defines terms

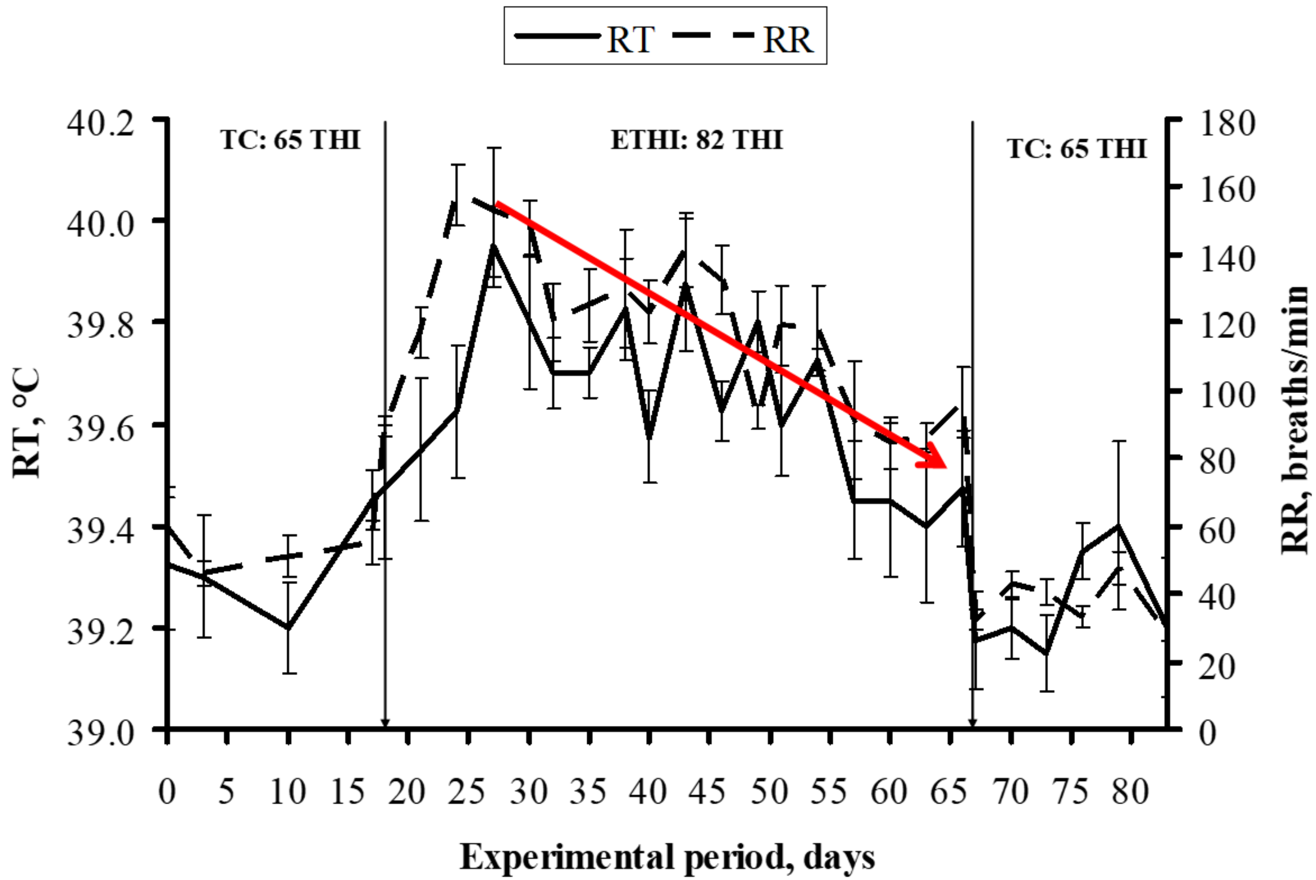
Acclimation/Acclimatization: physiological or behavioural changes occurring within the lifetime of an organism which reduces the strain caused by experimentally-induced or natural climate.

The terms acclimation and acclimatization are etymologically indistinguishable.

Adaptation: changes that reduce the physiological strain produced by stressful components of the total environment.

Adaptation, phenotypic (nongenetic): occurring within an organism's lifetime.
Adaptation, genotypic: a genetically fixed condition of a species or subspecies, or its evolution, which favours survival in a particular total environment.

Changes of rectal temperature in Sardinian female lambs



Bernabucci et al., 2009

Biological consequences of acclimation

Health
Reproduction
Production

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Carta dell'indice bio-climatico
(*basato sul THI*)

RELATIVE HUMIDITY, %

TEMPERATURE, °C	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
15	58	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59
16	59	59	59	60	60	60	60	60	60	60	60	60	60	60	60	60	61	61	61	61
17	60	60	60	61	61	61	61	61	61	61	61	62	62	62	62	62	62	62	62	63
18	61	61	61	62	62	62	62	62	62	63	63	63	63	63	64	64	64	64	64	64
19	62	62	62	63	63	63	63	63	64	64	64	64	65	65	65	65	66	66	66	66
20	63	63	63	64	64	64	64	65	65	65	66	66	66	66	67	67	67	67	68	68
21	64	64	64	65	65	65	66	66	66	67	67	67	68	68	68	69	69	69	69	70
22	64	65	65	66	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72
23	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	73
24	66	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74	75	75
25	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
26	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	77	77	78	78	79
27	69	69	70	71	71	72	73	73	74	74	75	76	76	77	77	78	79	79	80	81
28	70	70	71	72	72	73	74	74	75	76	76	77	78	78	79	80	80	81	82	82
29	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	76	76	77	78	78	79	80	81	81	82	83	83	84
30	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	77	78	78	79	80	81	81	82	83	84	84	85	86
31	72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	77	78	79	80	80	81	82	83	84	85	85	86	87	88
32	73	74	75	76	77	77	78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	84	85	86	87	88	89	90
33	74	75	76	77	78	79	79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86	87	88	89	90	90	91
34	75	76	77	78	79	80	81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87	88	89	90	91	92	93
35	76	77	78	79	80	81	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	95
36	77	78	79	80	81	82	83	84	85	86	87	88	89	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97
37	77	79	80	81	82	83	84	85	86	87	89	90	91	92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	99
38	78	79	81	82	83	84	85	86	88	89	90	91	92	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100
39	79	80	82	83	84	85	86	88	89	90	91	92	94	95	96	97	99	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	83	85	86	87	89	90	91	93	94	95	97	98	99	101	102	103	104	106
42	82	83	84	86	87	89	90	91	93	94	95	97	98	99	101	102	104	105	106	108
43	83	84	85	87	88	90	91	92	94	95	97	98	100	101	102	104	105	107	108	109
44	83	85	86	88	89	91	92	94	95	97	98	99	101	102	104	105	107	108	110	111
45	84	86	87	89	90	92	93	95	96	98	99	101	102	104	105	107	108	110	111	113

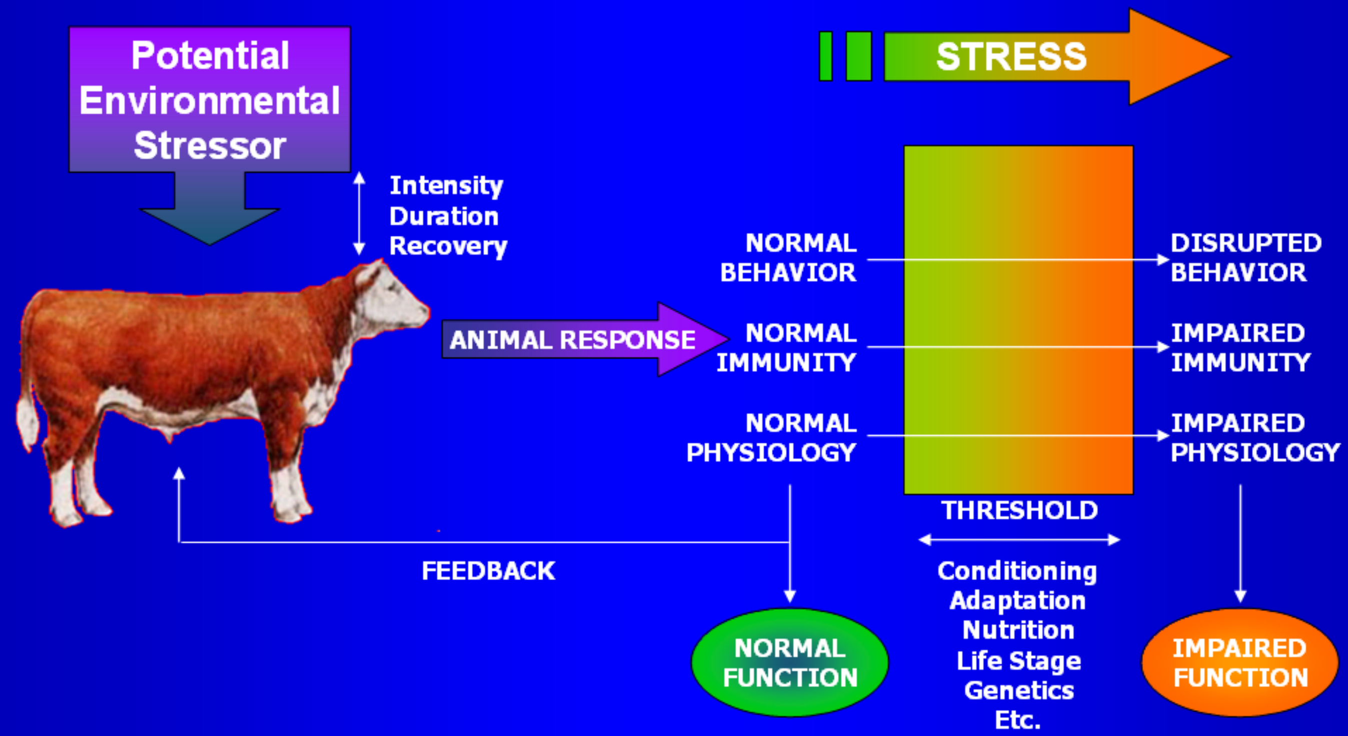
Allerta

Pericolo

Emergenza

Termoneutralità	<72	
Rischio minimo	73-78	Stress da caldo
Allerta	79-84	Stress da caldo
Emergenza	>84	Stress da caldo

Biological Response



Adapted by Hahn, 1999

IMPAIRED HEALTH PERFORMANCES

Health

Biological consequences of acclimation

Health

"High ambient temperatures are associated with higher incidence of health problems"

(*Martin et al., 1975; Kadzere et al., 2002; Lopes-Gatius et al., 2002*)

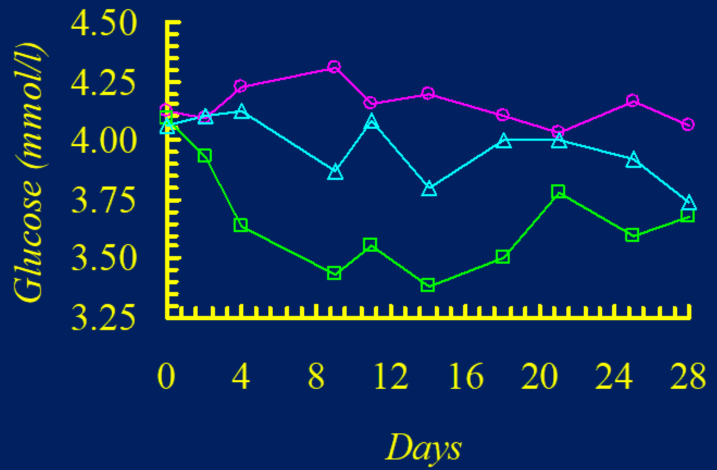
Metabolic diseases → increased incidence

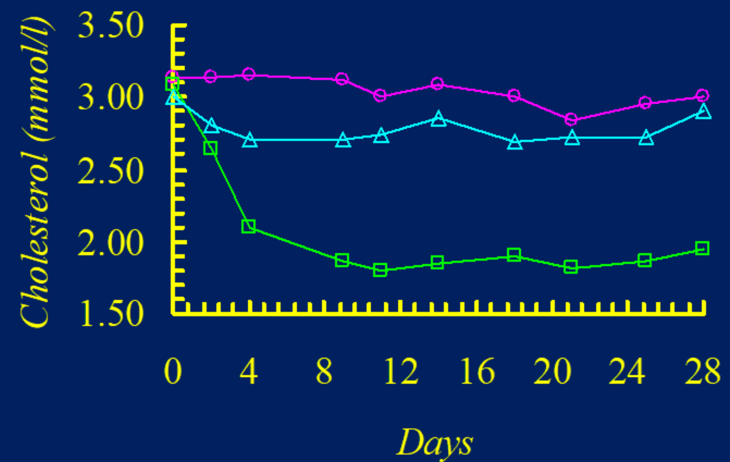
Defensive mechanisms → altered

Mortality → increased

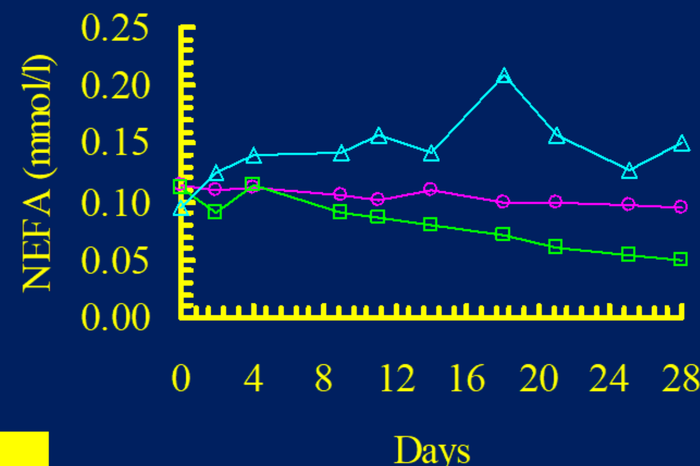
Basiricò et al., 2009; Bernabucci et al., 2002a; Dechow and Goodling, 2008; Hahn, 2002; Lacetera et al., 2005; 2006; Nardone et al., 1997; Vitali et al., 2009; Waage et al., 1998

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





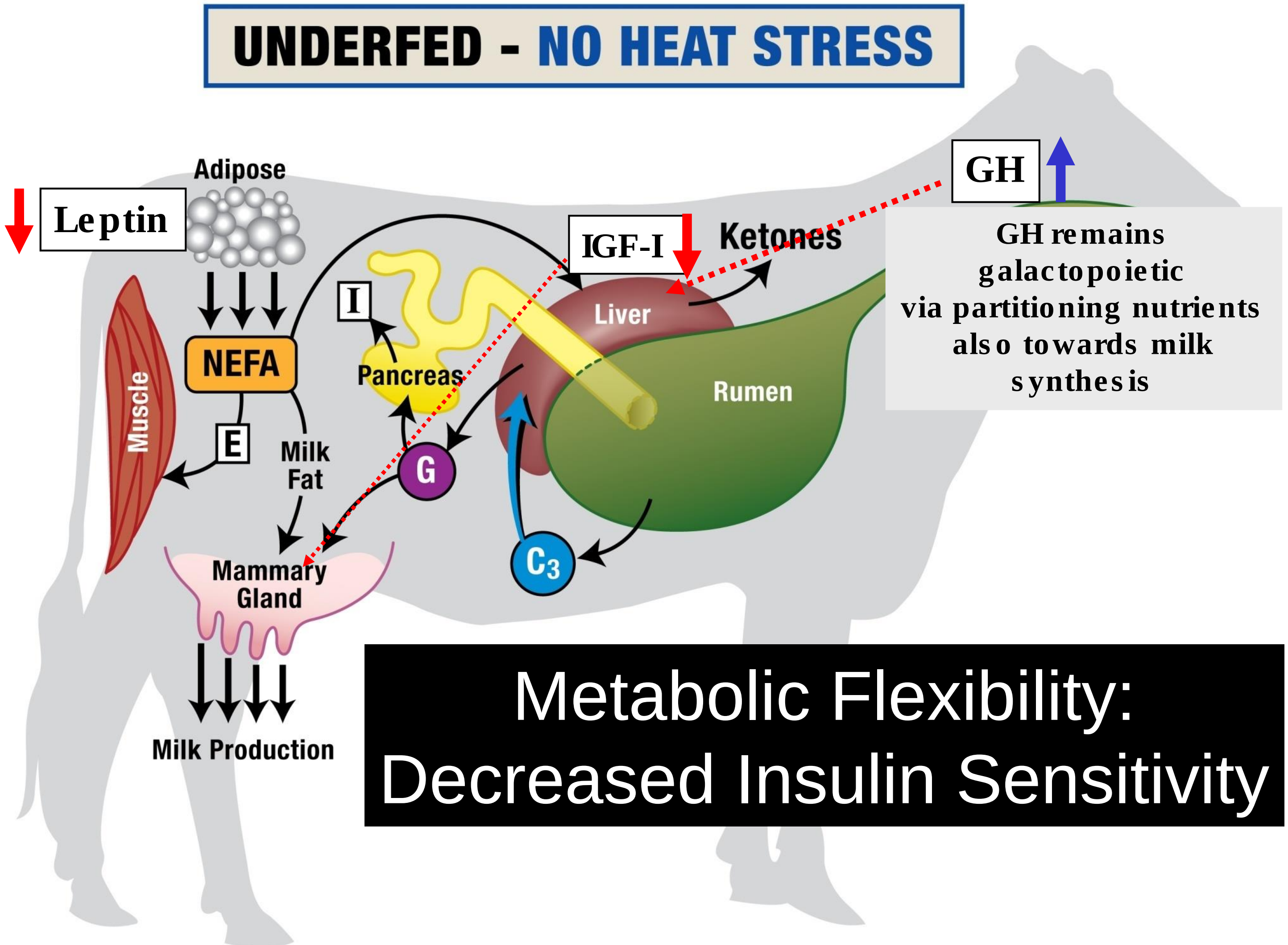
↓Hepatic enzymes
↓ Albumin
↓ Cholesterol
↑ Bilirubine



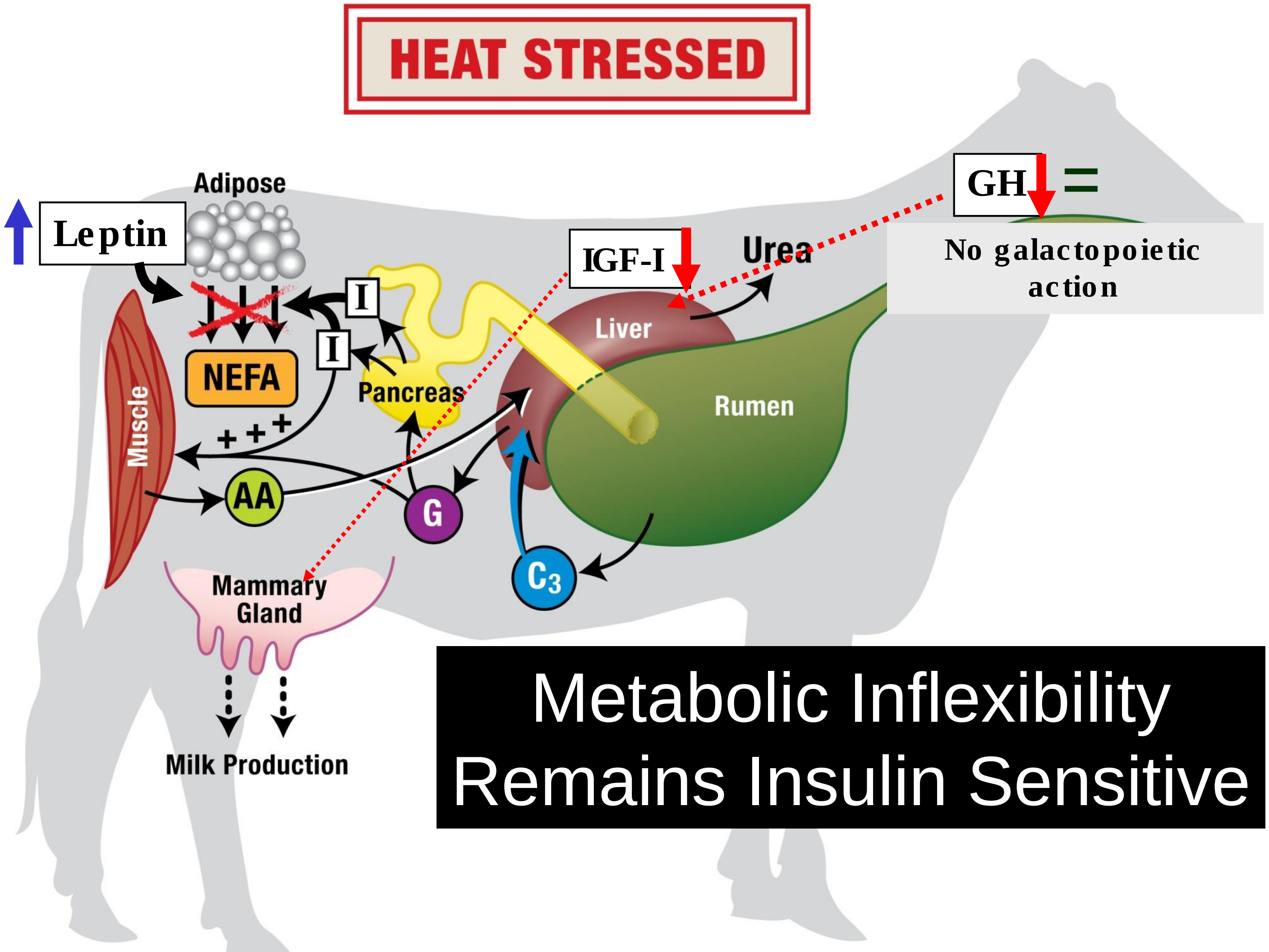
Reduction of liver metabolic and synthesis activities ?

(Ronchi et al., 1999)

NEBAL


UNDERFED - NO HEAT STRESS
Leptin
Adipose
NEFA
Muscle
E
Milk Fat
I
Pancreas
G
IGF-I
Ketones
GH
Liver
Rumen
C3
Mammary Gland
Milk Production
GH remains galactopoietic via partitioning nutrients also towards milk synthesis
Metabolic Flexibility: Decreased Insulin Sensitivity

NEBAL



Metabolic Inflexibility
Remains Insulin Sensitive

Livestock Science 137 (2011) 49–57
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Livestock Science
journal homepage: www.elsevier.com/locate/livsci
ELSEVIER

Down-regulation of hepatic $ApoB_{100}$ expression during hot season in transition dairy cows

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The case of transition cows

J. Dairy Sci. 98:5401–5413
http://dx.doi.org/10.3168/jds.2015-9409

The effect of calving in the summer on the hepatic transcriptome of Holstein cows during the peripartal period

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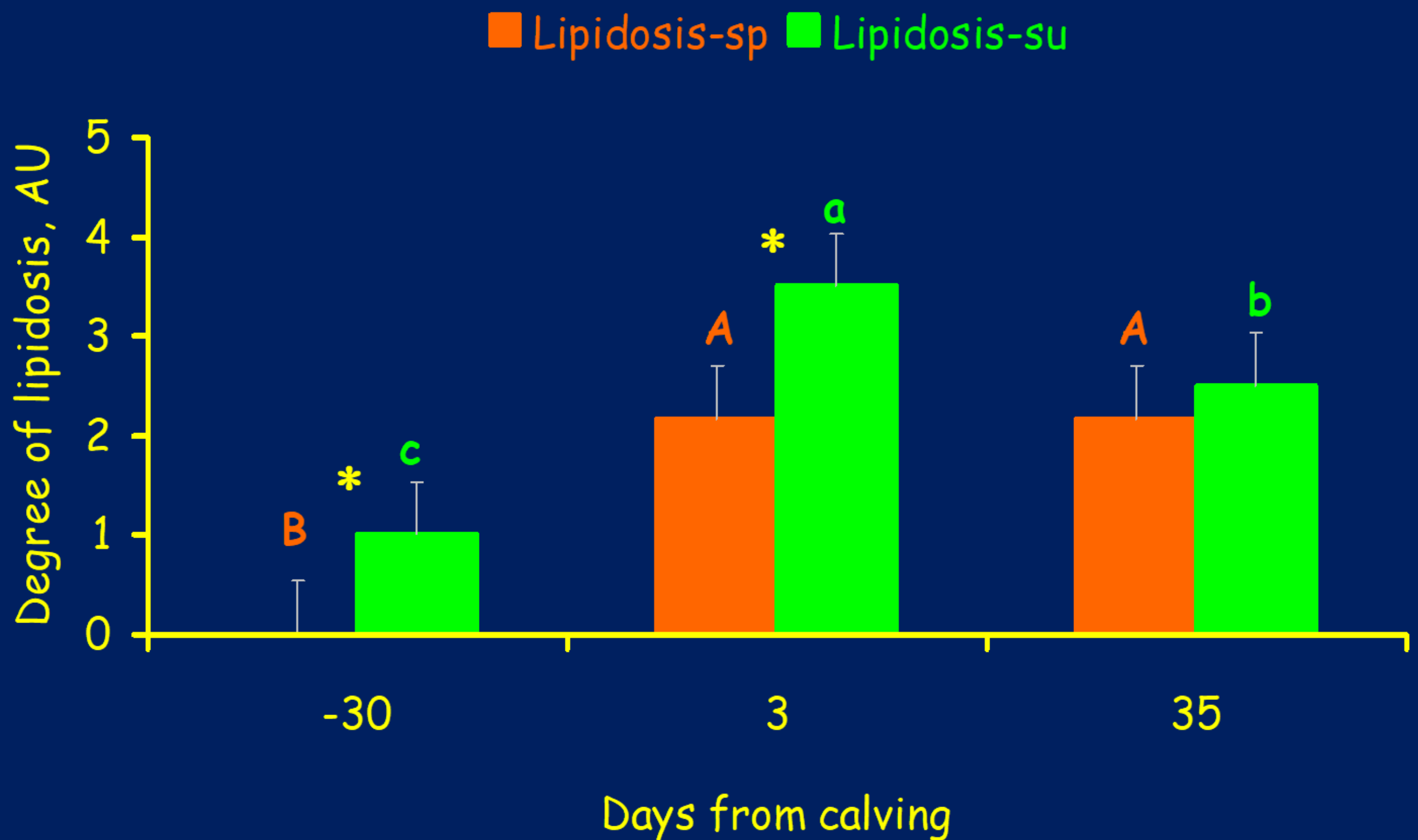
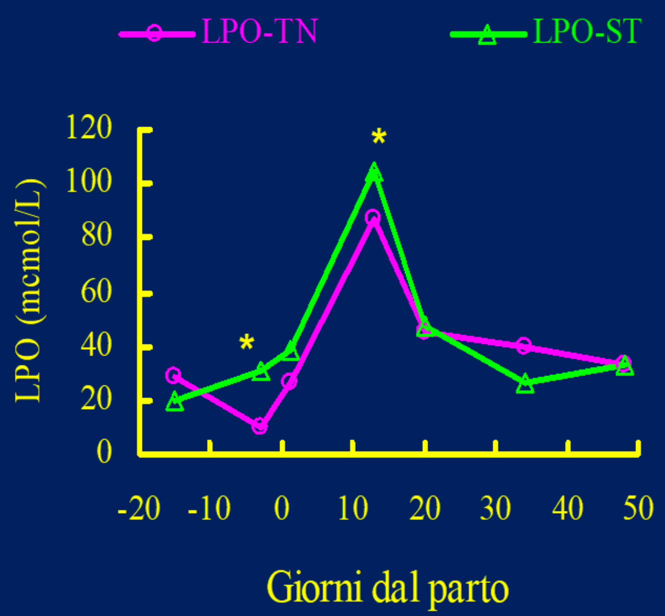
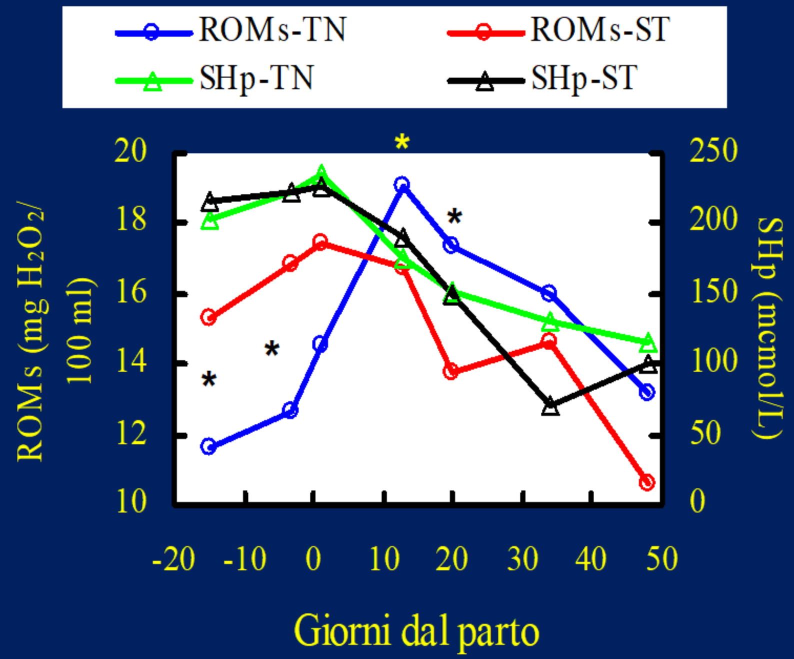
Lipid accumulation in liver of SP and SU cows



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

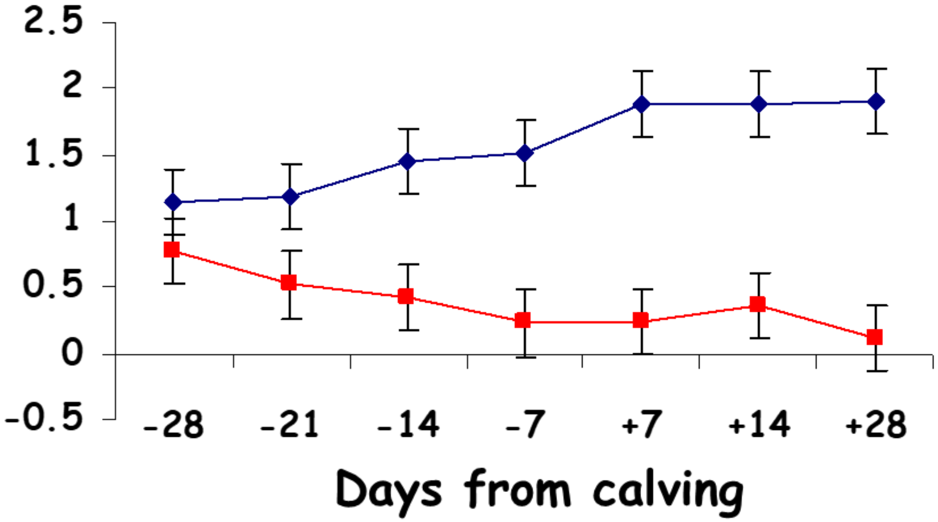




Changes in lipoperoxidation (LPO), reactive oxygen metabolites (ROMs) and thiol groups (SHp) in transitino dairy cows kept under thermoneutral (TN) and heat stress conditions (ST). * = *P<0,05*

Bernabucci et al., 2002, 2003, 2005

Lymphocyte function was strongly altered in heat-stressed periparturient dairy cows



Dairy cows: in vivo study

Day-time THI: > 80
RT: > 40 C°
RR: > 80 breaths·minute

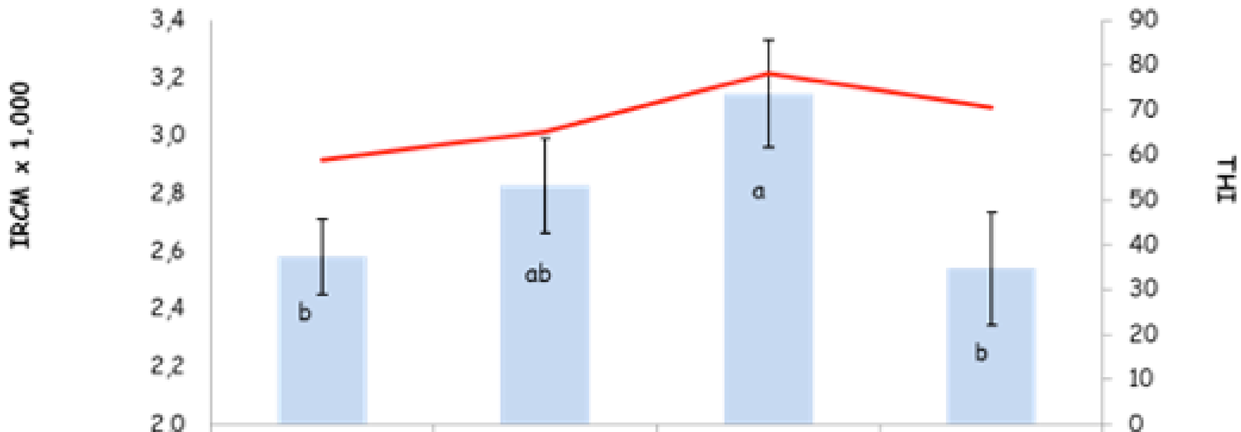
Spring
Summer

Lacetera et al., 2006

Lacetera et al., 2002: moderate HS did not affect significantly proliferation of mitogens-stimulated PBMCs

Infezione intramammaria in primipare

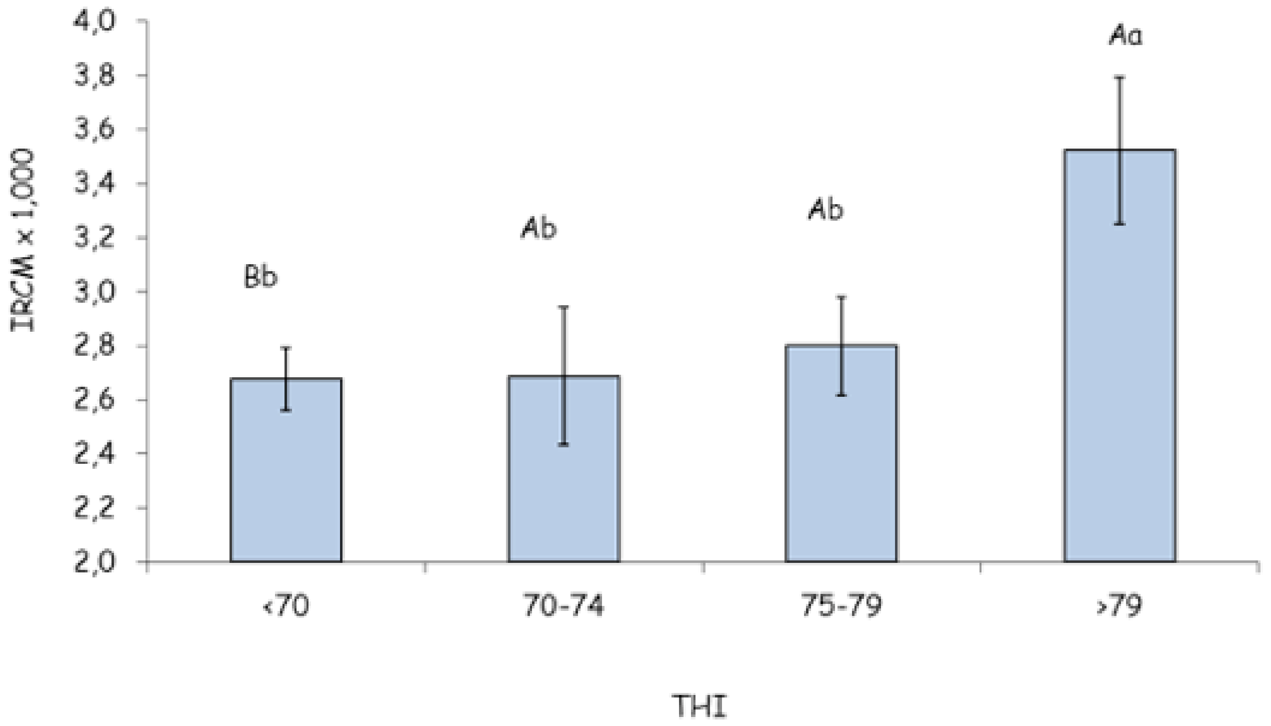
Season

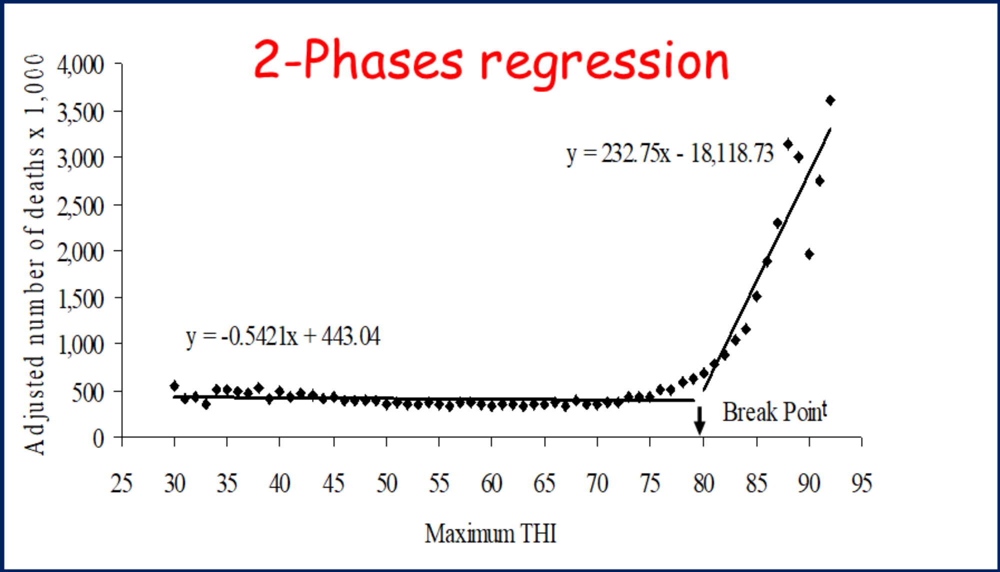


	winter	spring	summer	fall
IRCM	2,58	2,83	3,15	2,54
THI	58,9	65,2	78,1	70,5

Infezione intramammaria in primipare

Classes of THI

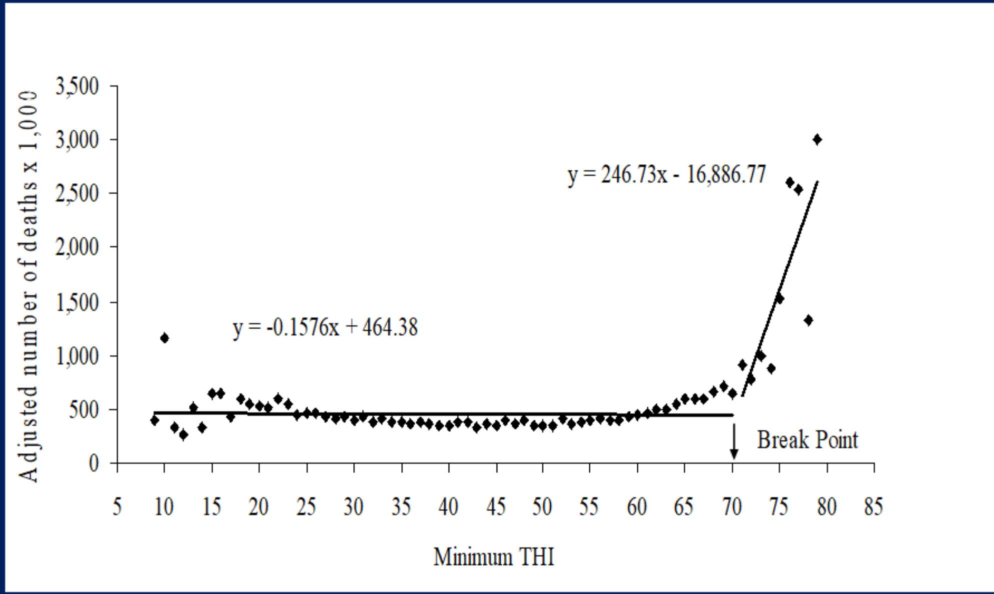




Daily maximum THI

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

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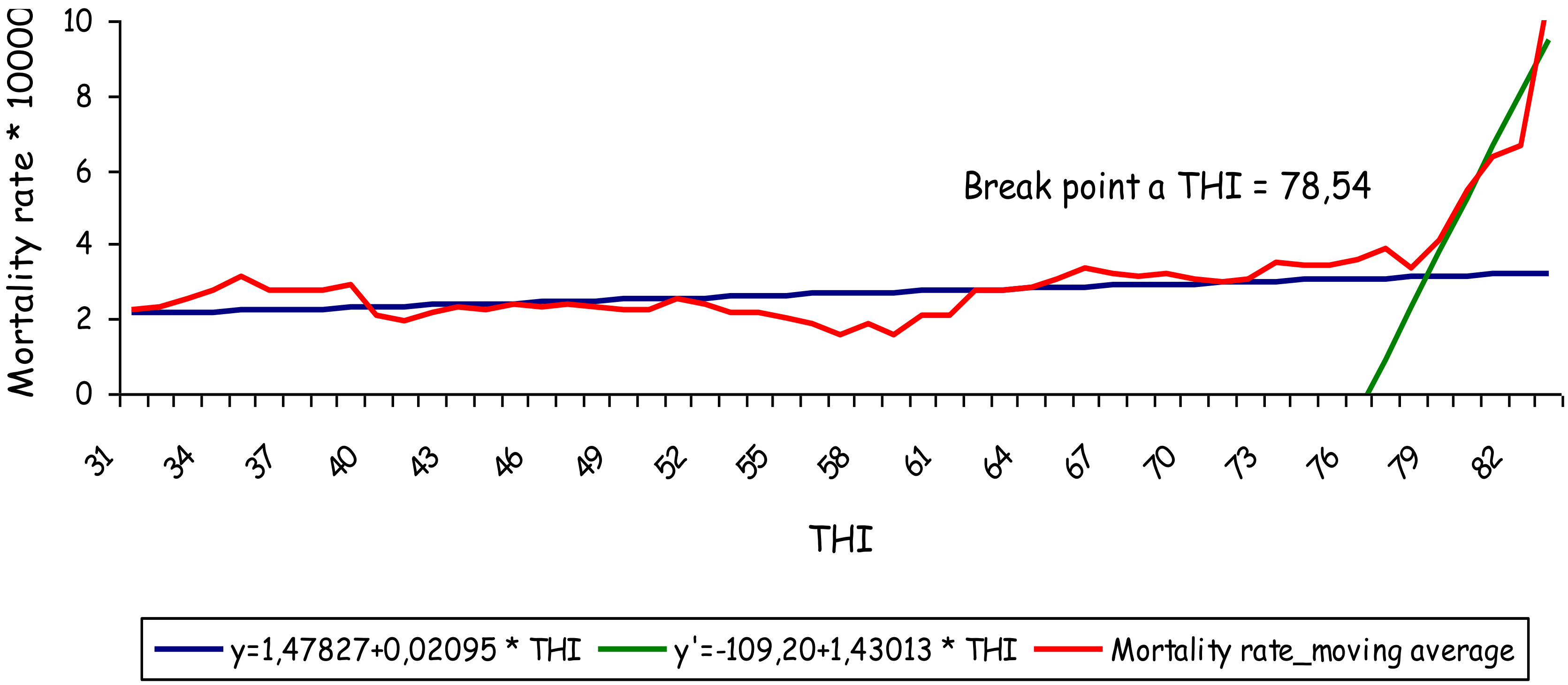
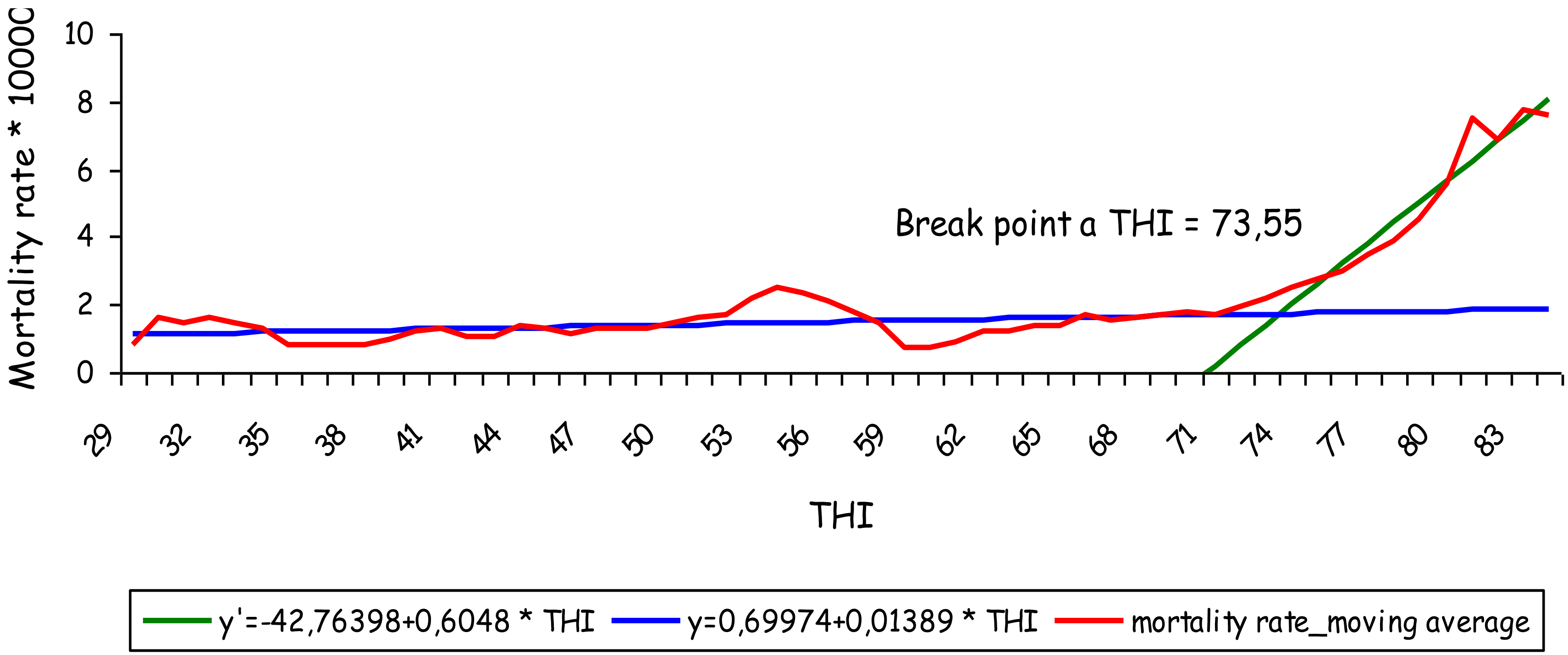
Two phases regression_in transit pigs losses



In-transit mortality rate of pigs in relation to temperature-humidity index (THI).

Two phases linear regression_lairage pigs losses



Mortality rate at lairage of pigs in relation to temperature-humidity index (THI).

Reproduction

Seasonal heat stress

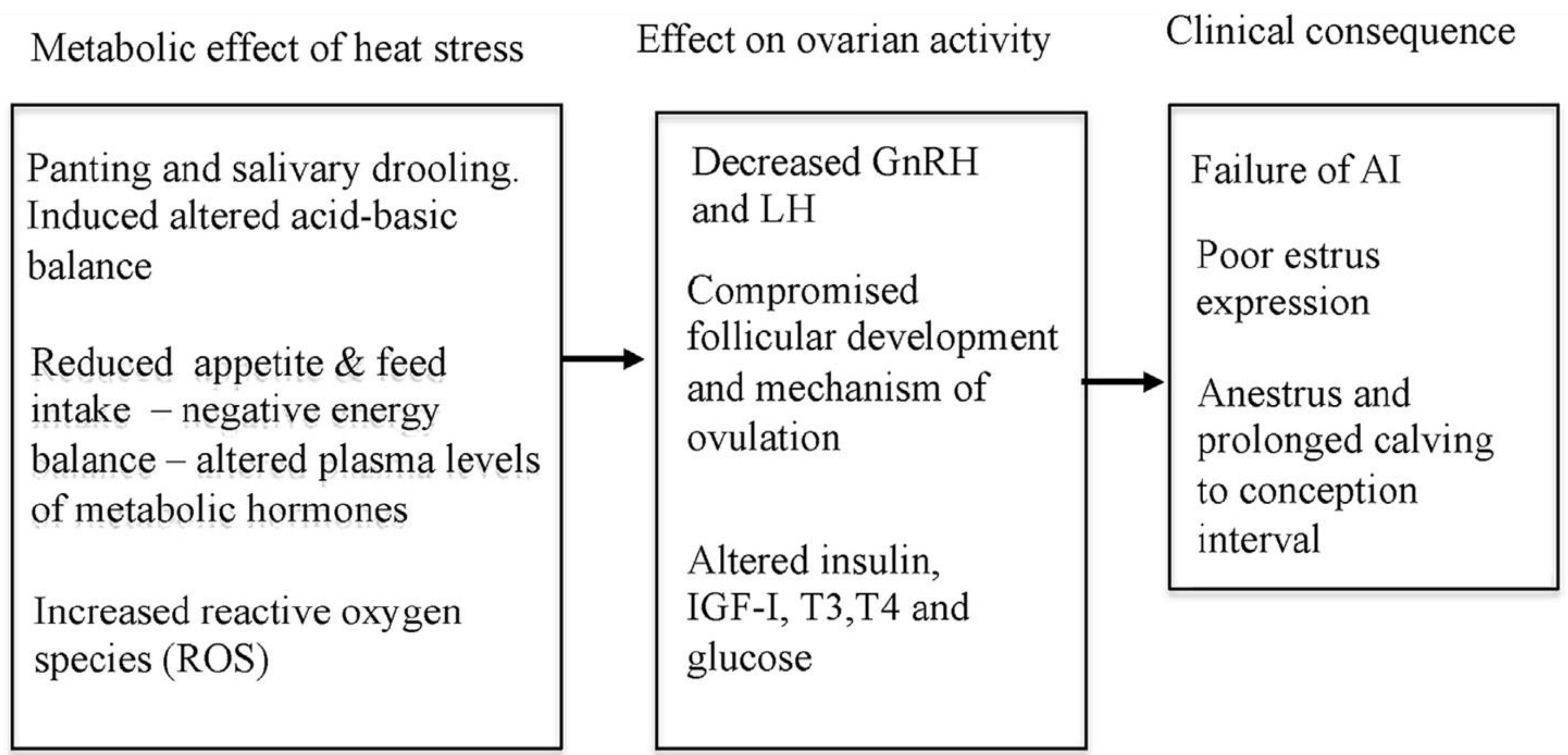
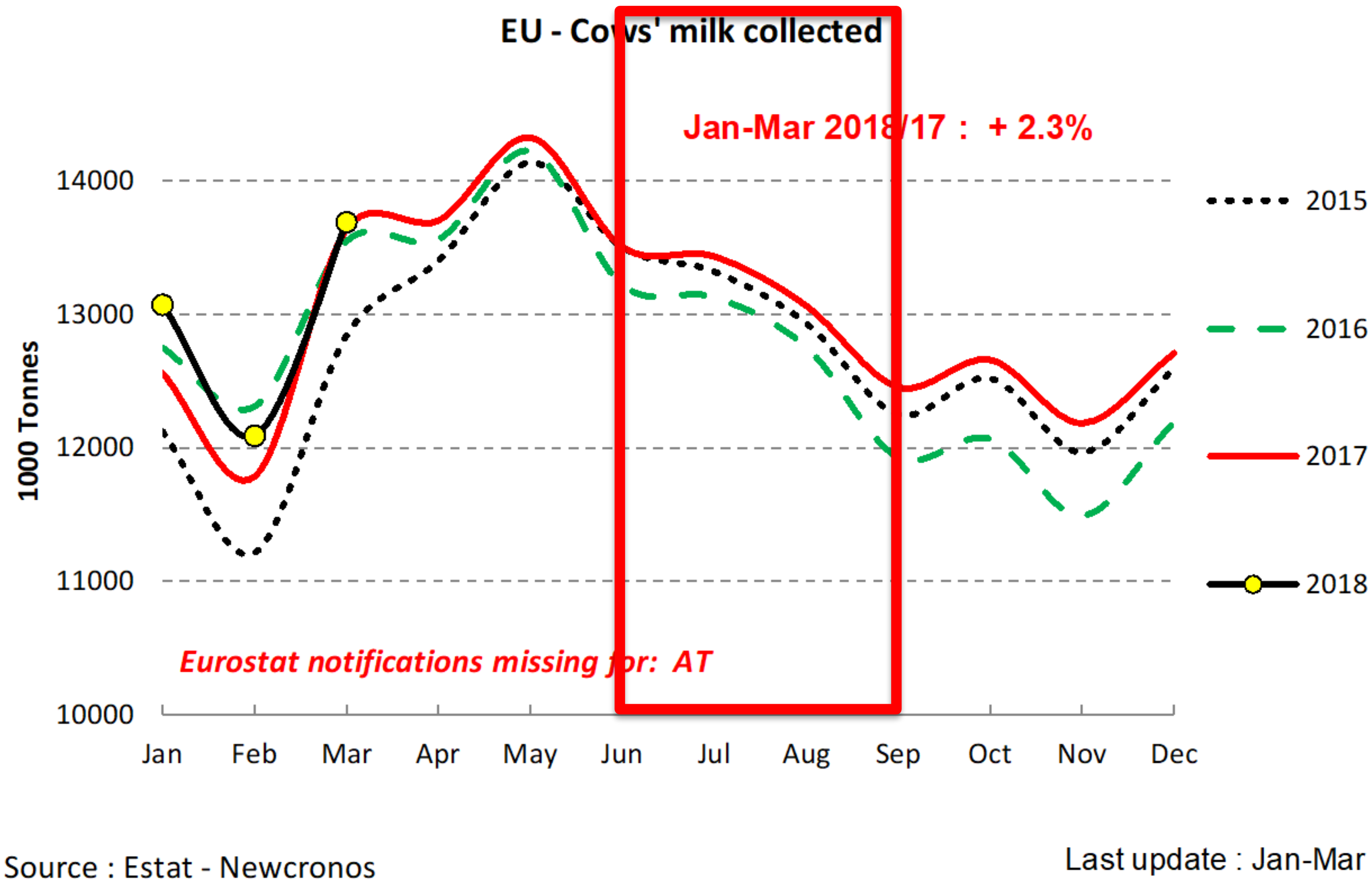


Fig. 1. The main metabolic mechanisms that effect reproduction during periods of seasonal heat stress in dairy cows.

Ronchi et al., 1995; Bernabucci et al., 2010; De Rensis et al., 2017

Production - milk


EU - Cows' milk collected
Jan-Mar 2018/17 : + 2.3%
1000 Tonnes
14000
13000
12000
11000
10000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2015
2016
2017
2018
Eurostat notifications missing for: AT
Source : Estat - Newcronos
Last update : Jan-Mar

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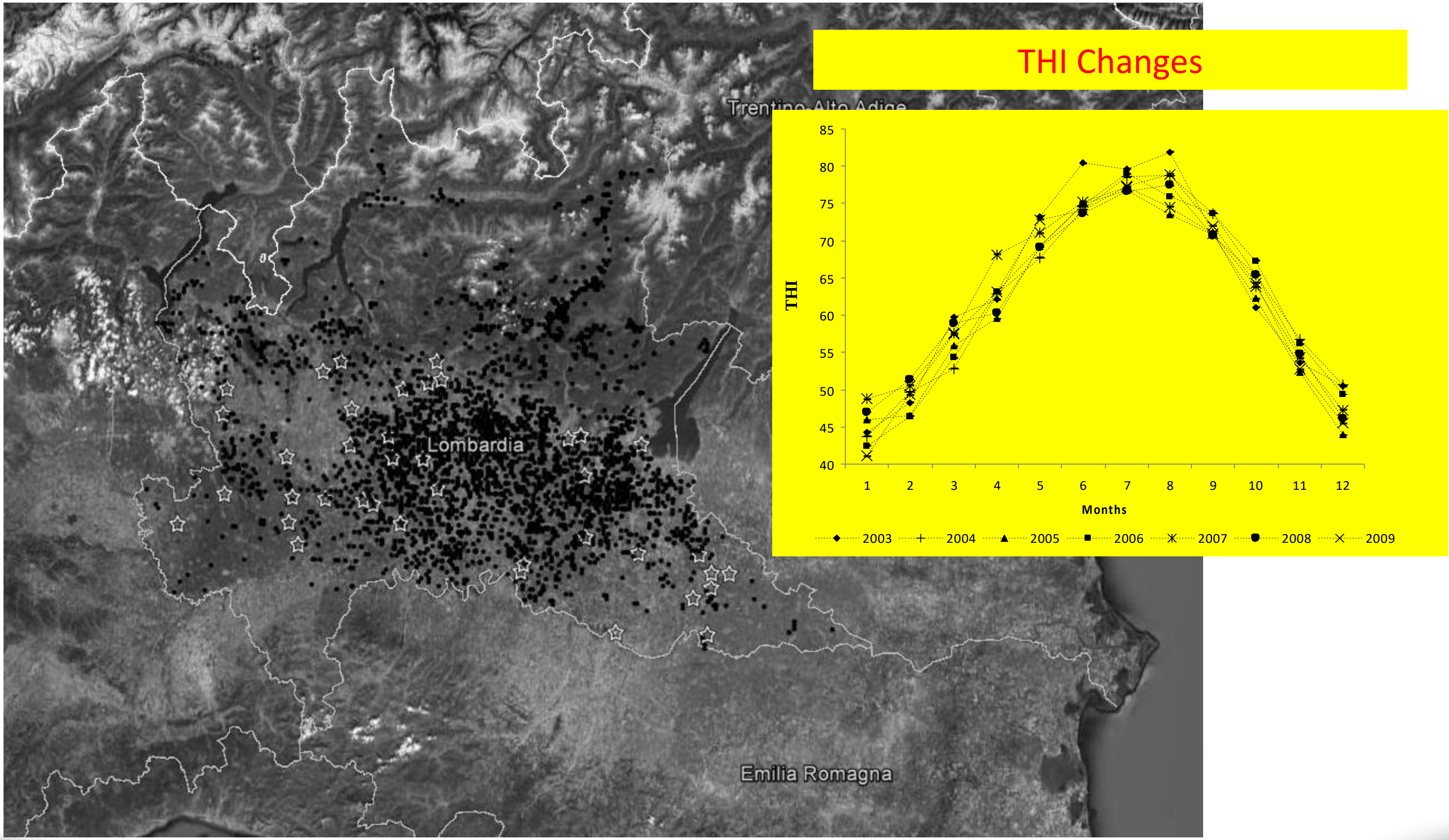
Retrospective study – 1°



Bertocchi et al., 2014

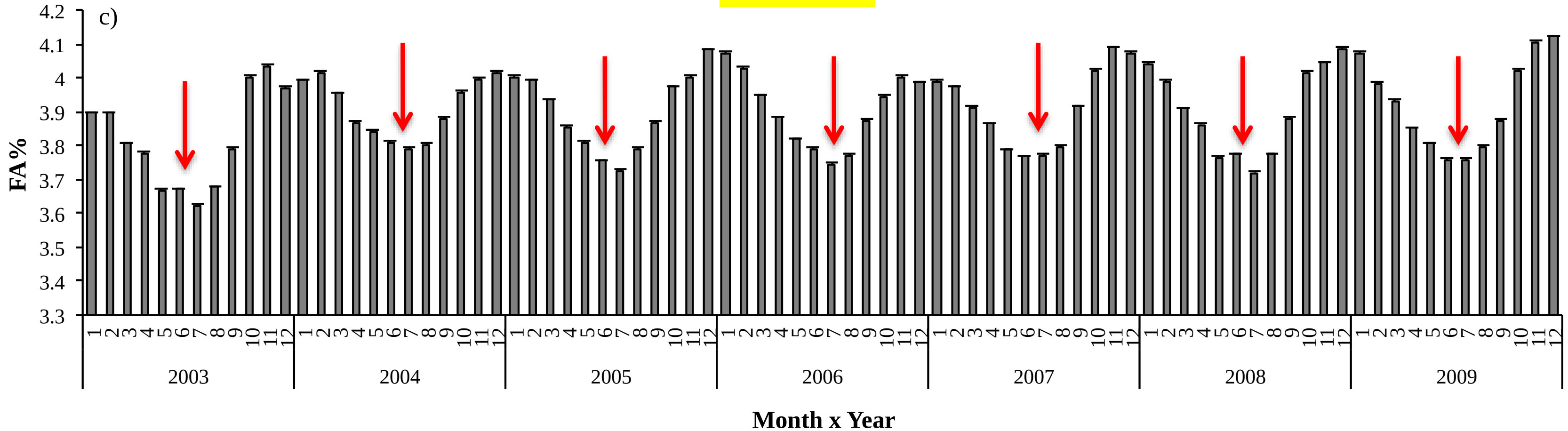
Table 1 *Descriptive statistics of the studies*

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

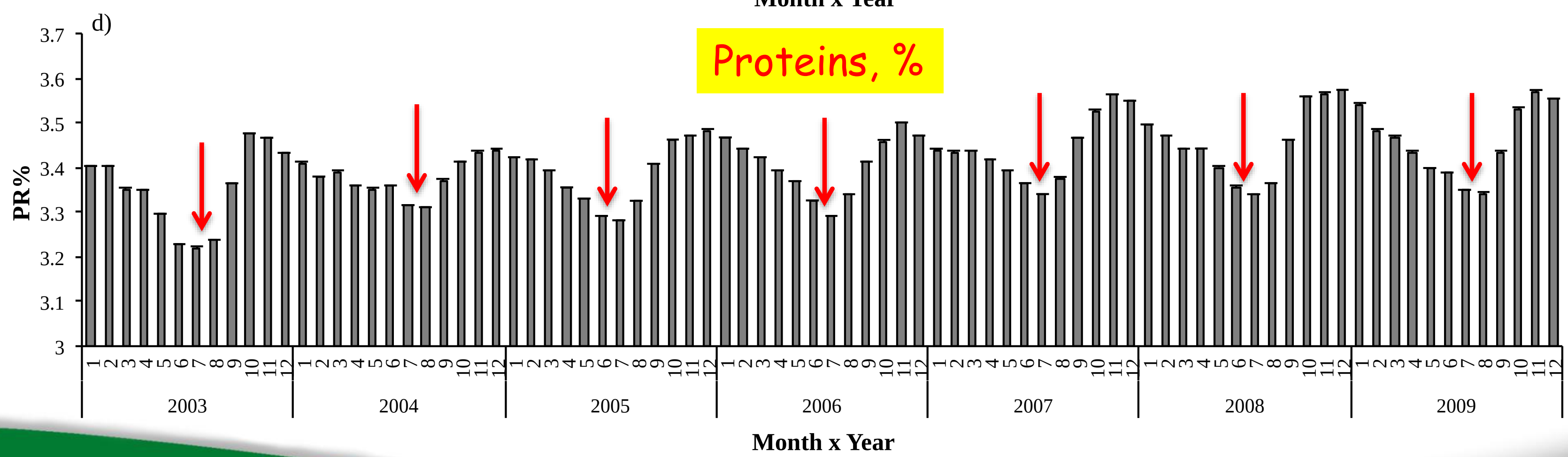
THI = temperature–humidity index.

Month x Year: fat and proteins, %

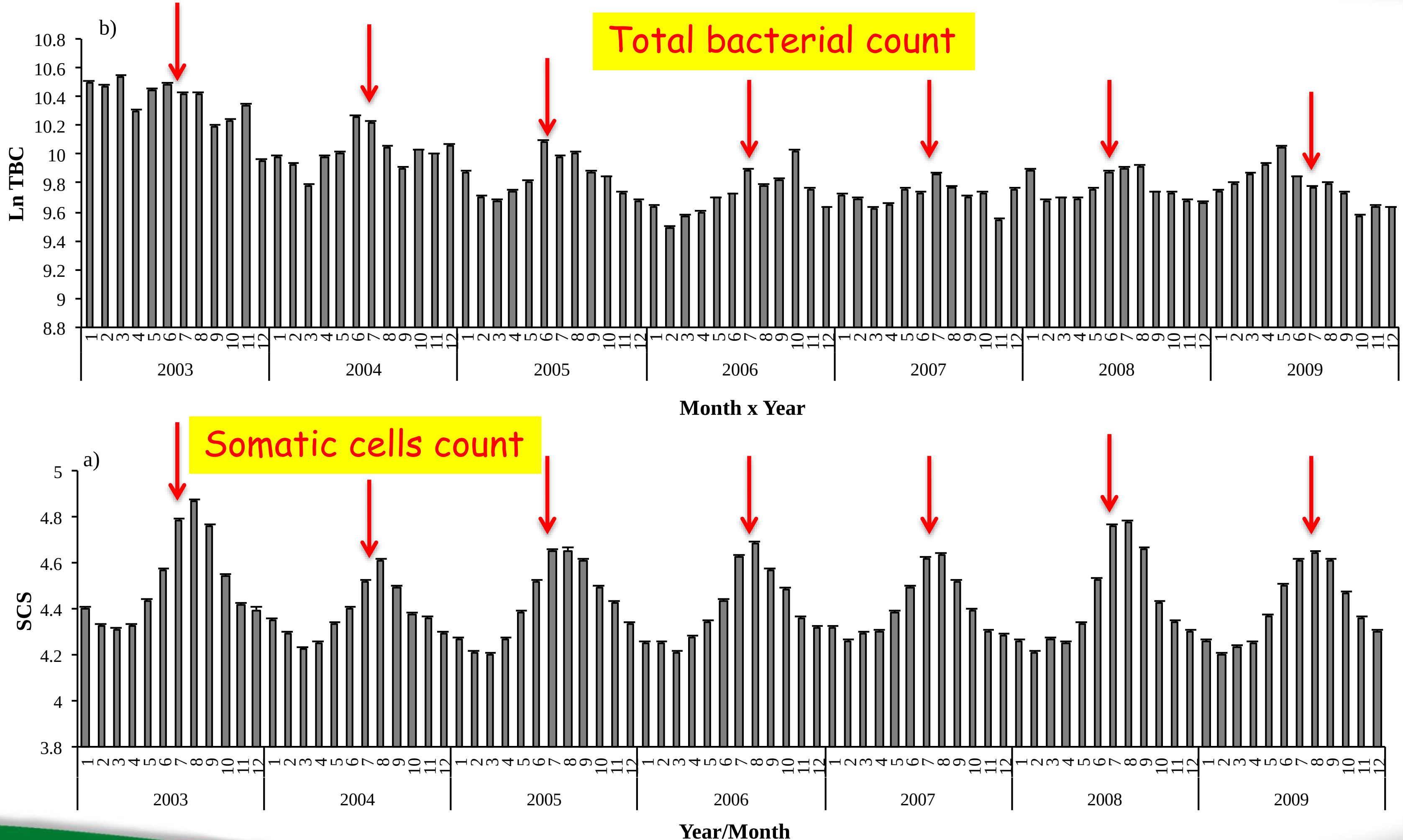
Fat, %



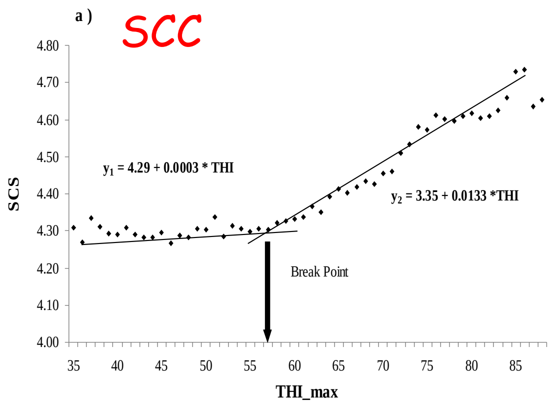
Proteins, %

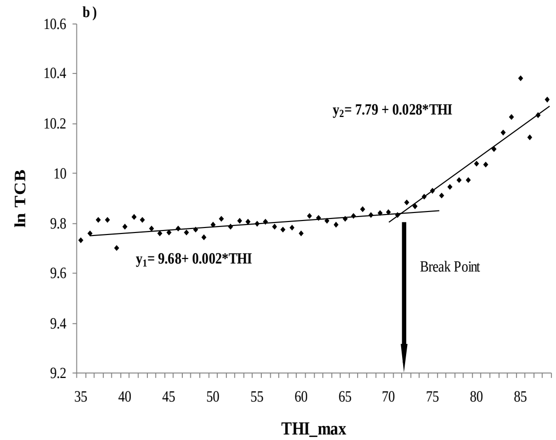


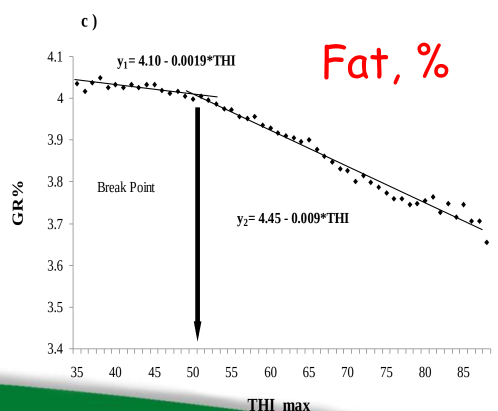
Month x Year: TBC e SCC

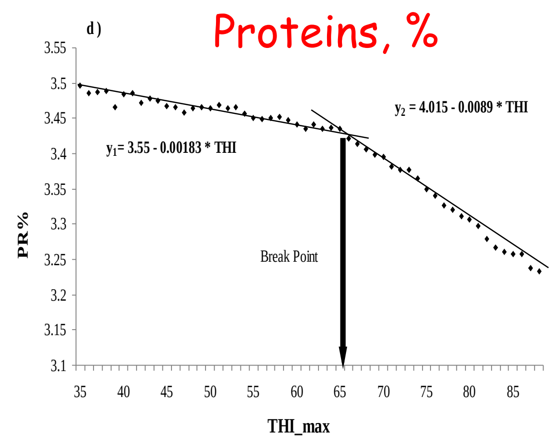


Relationships between THI and Milk characteristics









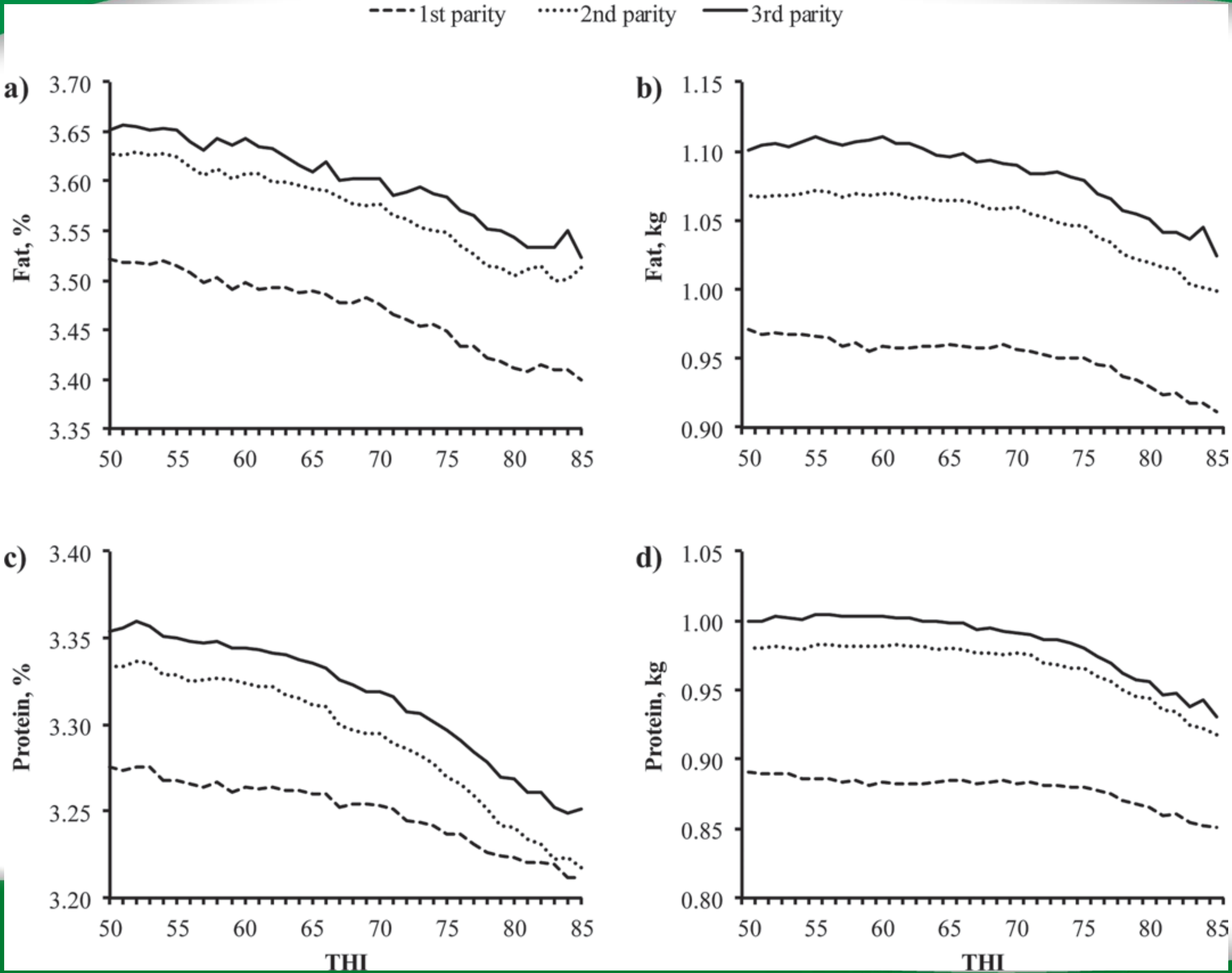
Break points:

57.3 THI for (a) SCC;

72.8 THI for (b) TBC;

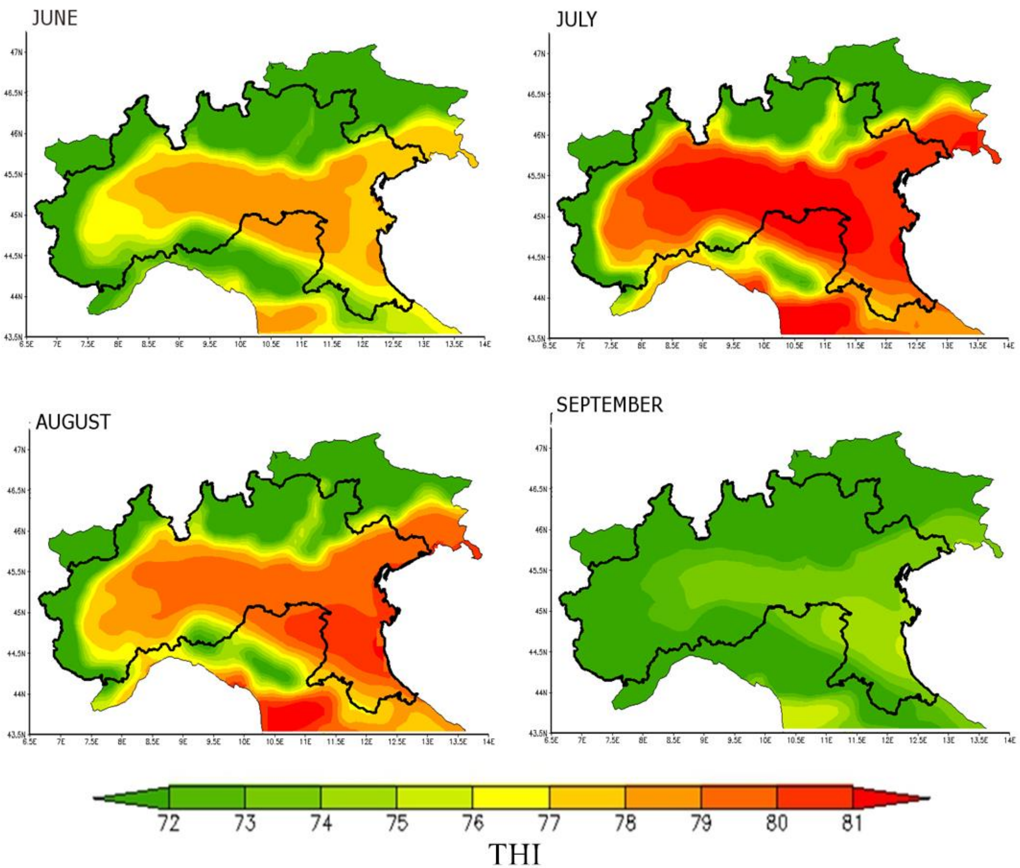
50.2 THI for (c) Fat %;

65.2 THI for (d) Pr %.



Bernabucci et al., 2014

THI-related risk of milk, protein and fat yield loss (kg/d) in the production area of Grana Padano (marked) during the period **2021–2050** in the months of June, July, August and September (Vitali et al., 2019).



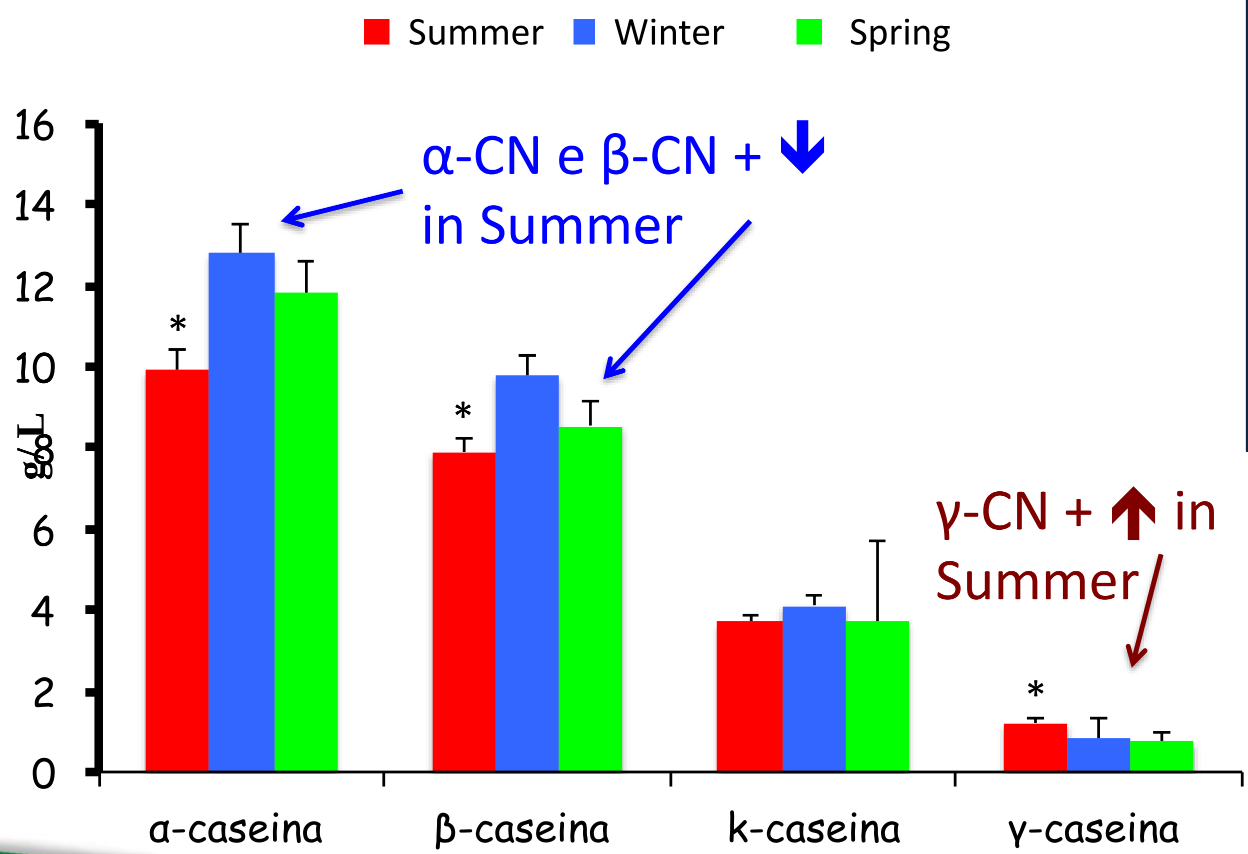
MILK (kg/d)	PROTEIN (kg/d)	FAT (kg/d)
-	-	-
-	0.051	0.053
-	0.103	0.106
-	0.154	0.160
1.050	0.205	0.213
2.099	0.257	0.266
3.149	0.308	0.319
4.198	0.359	0.372
5.248	0.411	0.425
6.297	0.462	0.479
7.347	0.514	0.532

Experimental trial (Bernabucci et al., 2015)

Dairy cows, same farm, two types of barns with different characteristics.
At least 4 dataloggers (t°, UR) for 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

Table 7. The effect of heat stress and restricted intake on mean casein mass fractions during treatment (period 1, 7 d) and posttreatment (period 2, 7 d) periods (control, TN-AL; heat-stressed, HS; restricted intake, TN-R)

	Treatment group				
Item/period	TN-AL	HS	TN-R	SEM	*P*-value
α_{S1}-Casein					
Period 1	36.57[a]	38.41[b]	37.76[ab]	0.582	*
Period 2	37.01	36.16	35.76	0.375	
α_{S2}-Casein					
Period 1	13.45[a]	11.75[b]	14.37[a]	0.355	*
Period 2	13.50	14.04	14.01	0.367	
β-Casein					
Period 1	38.17	38.83	37.81	0.635	
Period 2	38.65	38.84	39.13	0.411	
κ-Casein					
Period 1	10.63	11.35	10.89	0.289	
Period 2	10.84	10.97	11.11	0.335	

[a,b]Different superscripts within periods within rows indicate significant differences between treatments.

*$P < 0.05$.

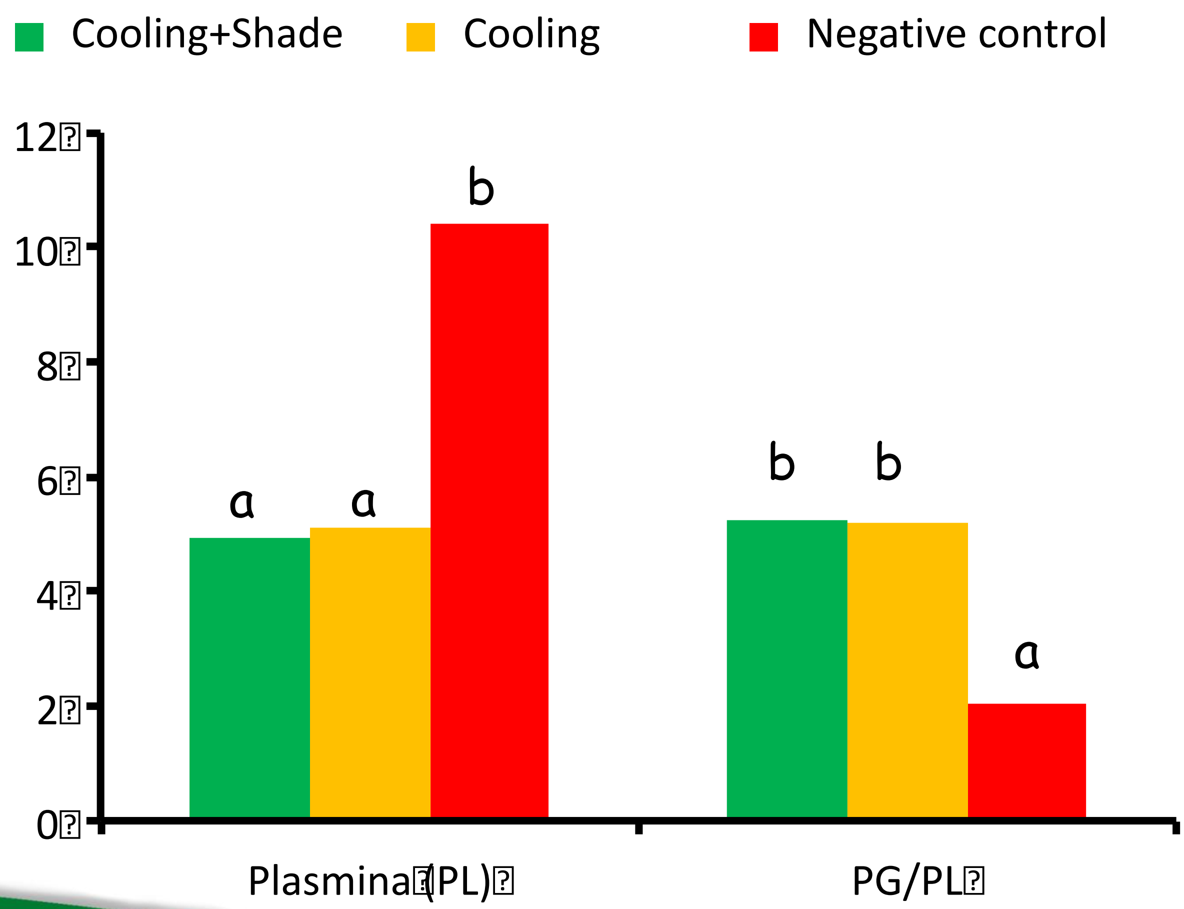
(Cowley et al., 2015)

Gellrich et al., 2014: lower concentration during summer

Han et al., 2011: heat stress reduces α-CN e β-CN mRNA

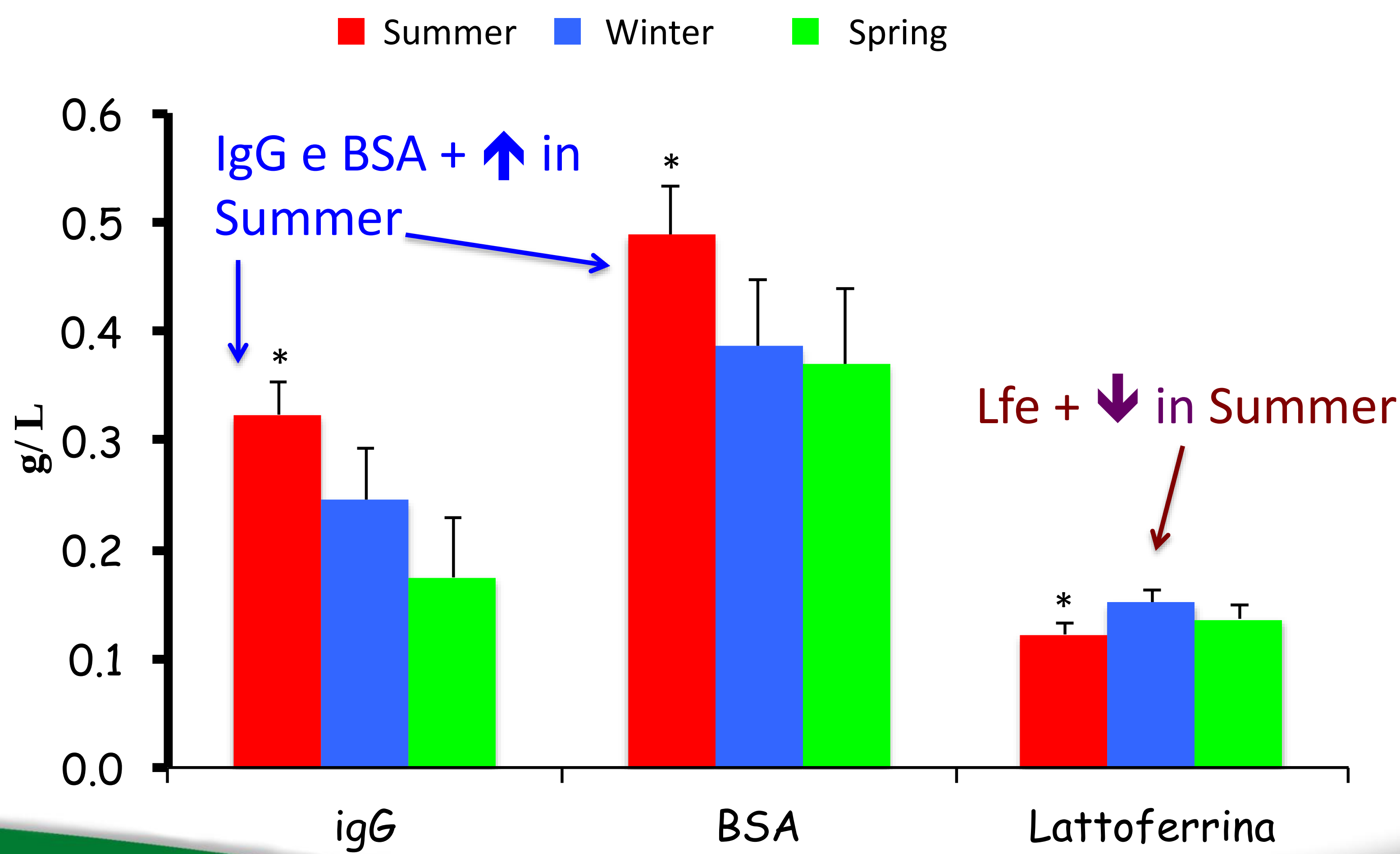
Salama et al., 2014: heat stress reduces α_{s1}-casein e α_{s2}-casein mRNA

Heat stress effects on milk plasmin activity

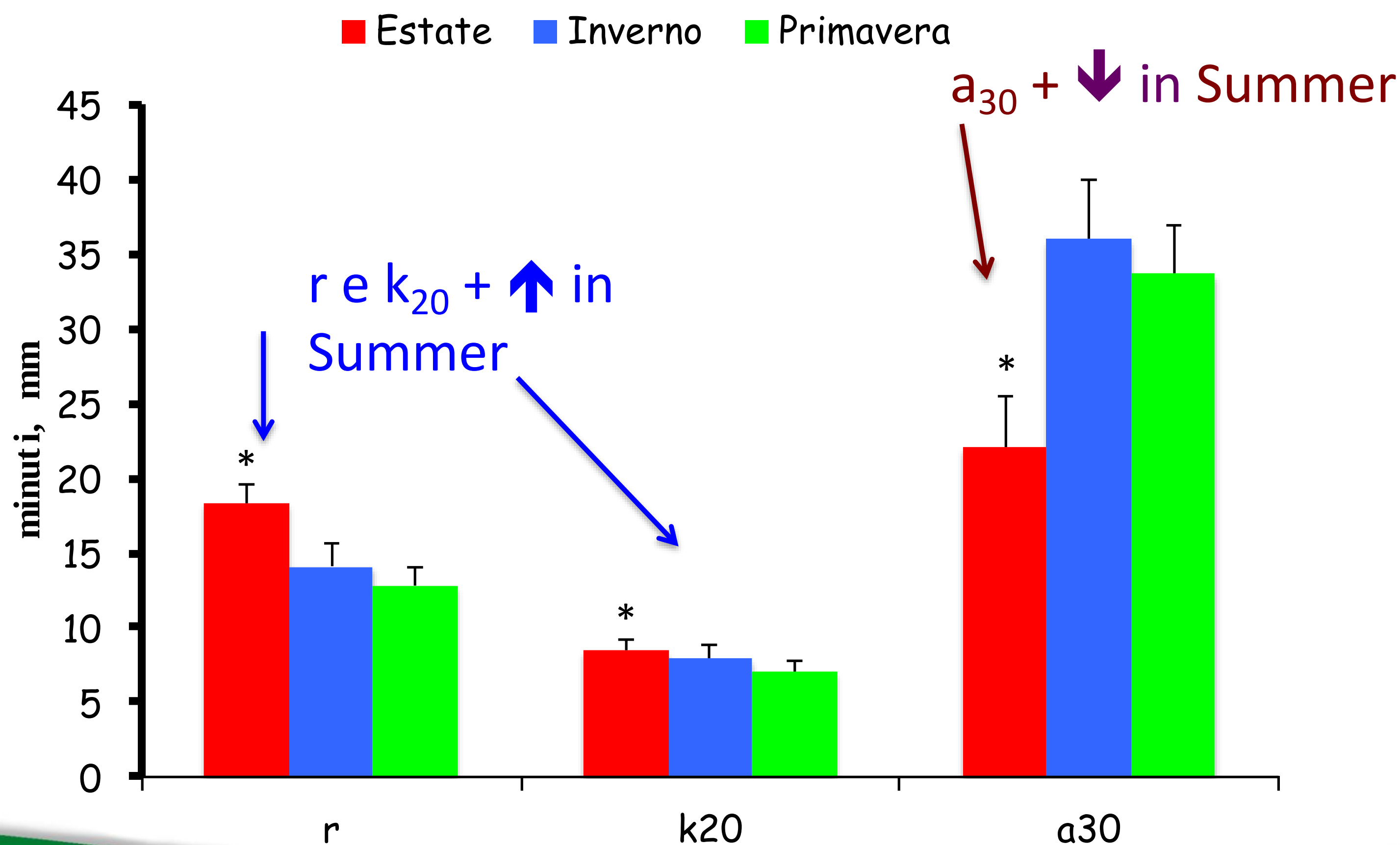


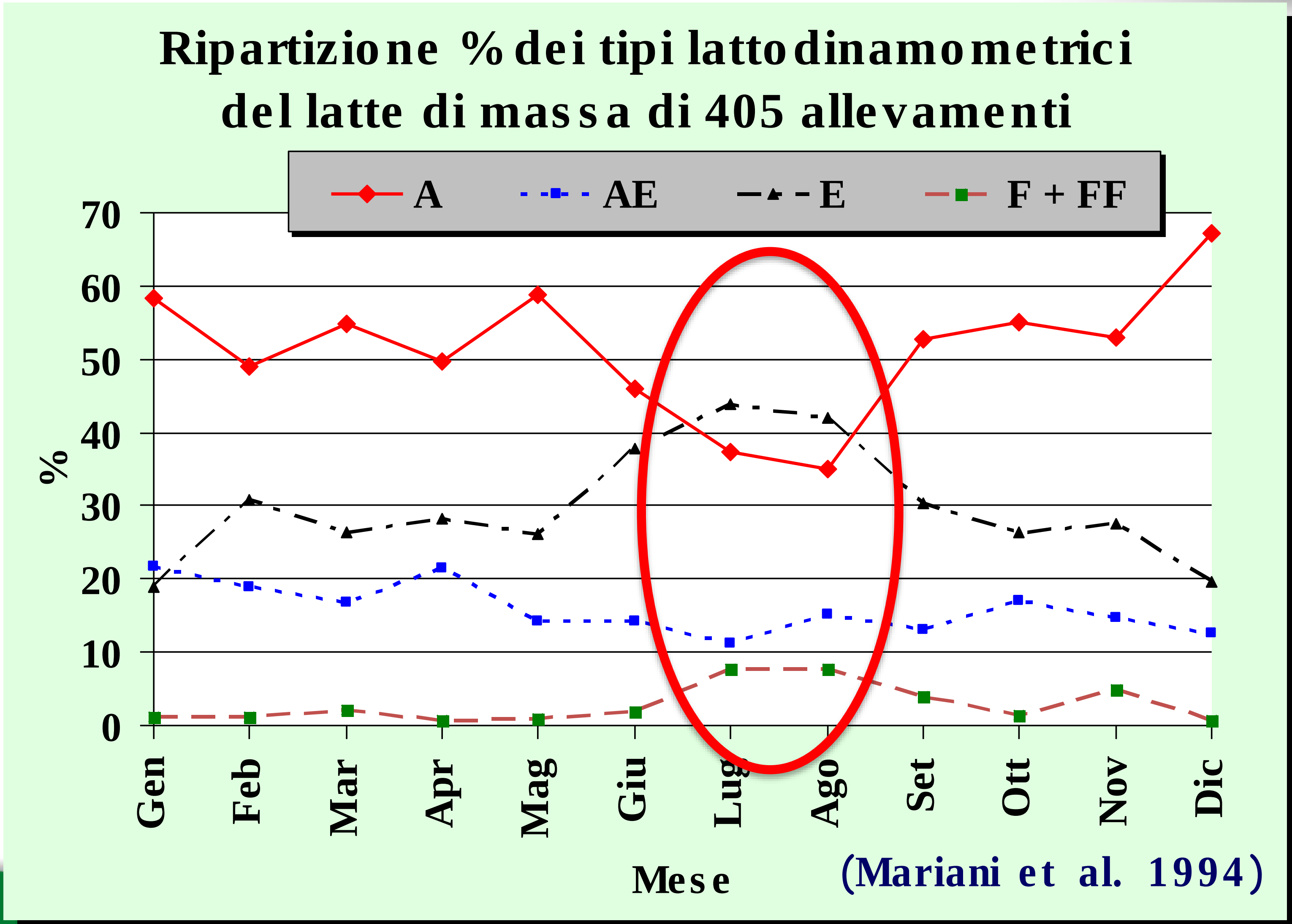
(Silanikove et al., 2009)

Milk serum proteins



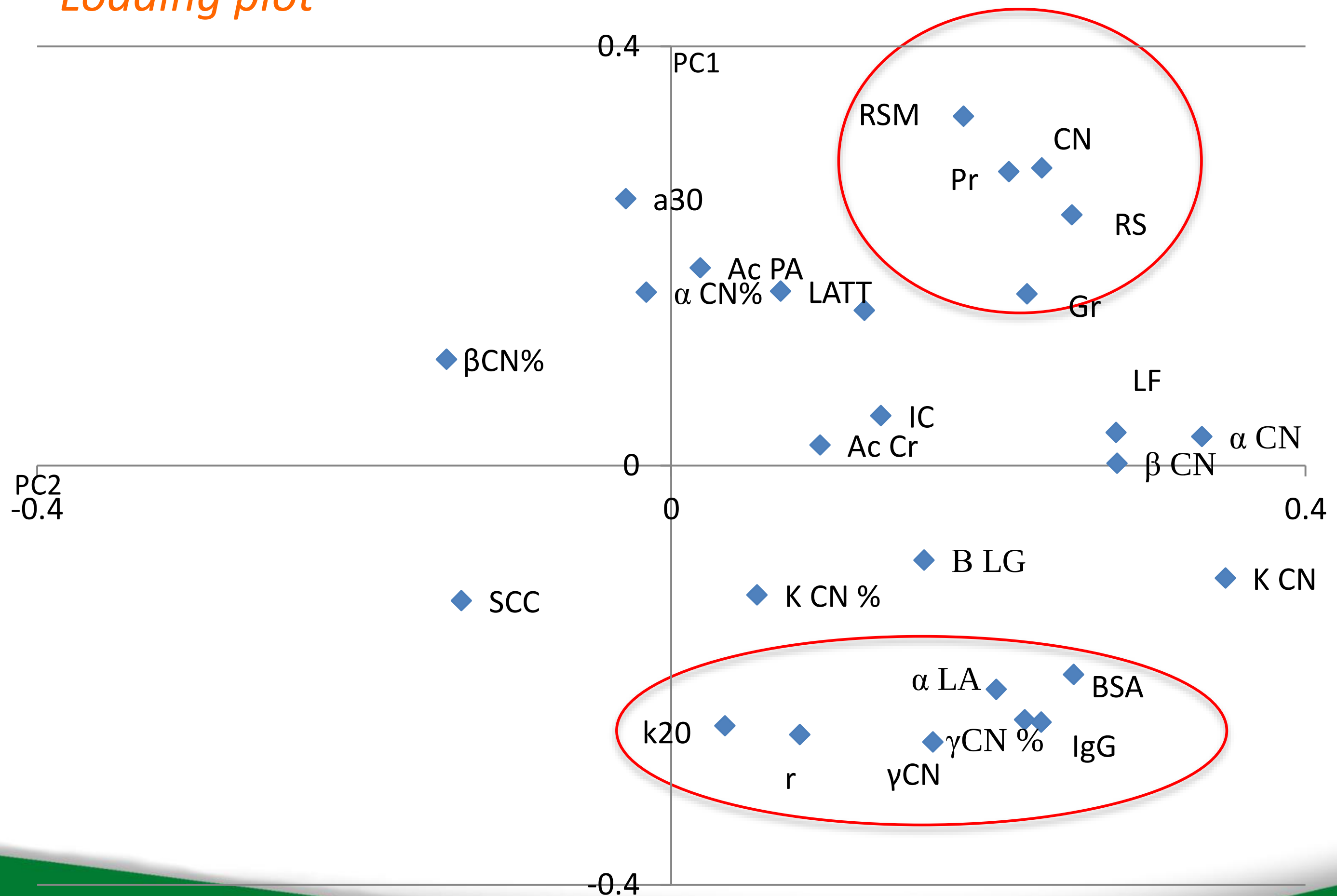
Tempo di coagulazione (r, min), velocità di formazione del coagulo (k_{20}, min) e consistenza della cagliata (a_{30}, mm)



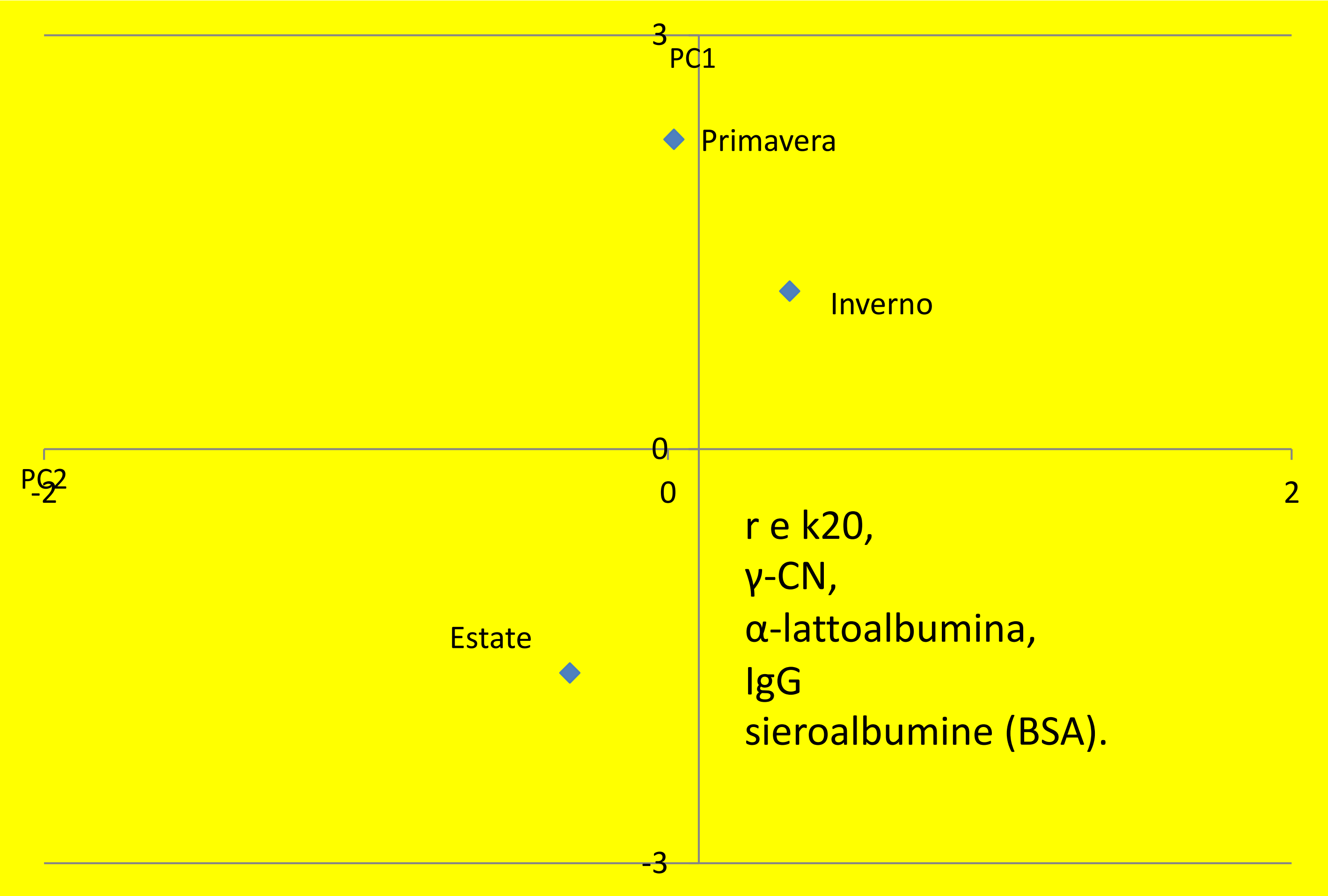

Ripartizione % dei tipi lattodinamometrici
del latte di massa di 405 allevamenti
A
AE
E
F + FF
70
60
50
40
30
20
10
0
%
Gen
Feb
Mar
Apr
Mag
Giu
Lug
Ago
Set
Ott
Nov
Dic
Mese
(Mariani et al. 1994)

Analisi discriminante

Loading plot



Analisi discriminante



Clostridium tyrobutyricum

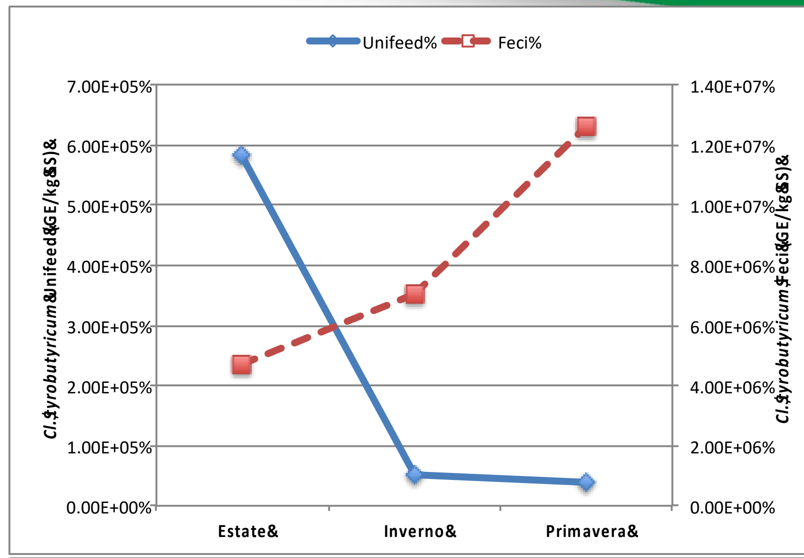
% of + samples to *Cl. tyrobutyricum*

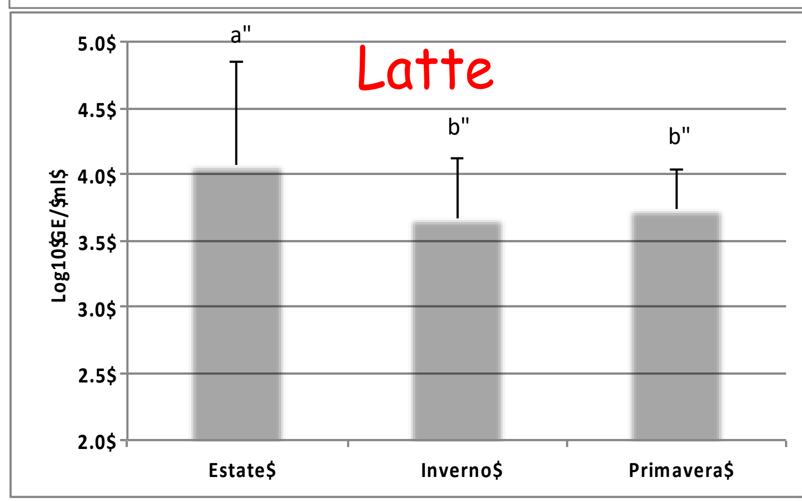
TMR:
- 100% sample (+) Su, Wi, Sp.

Feces:
- 95% (+) summer;
- 98% (+) Winter;
- 100% (+) Spring.

Milk:
- 23% (+) Summer;
- 36% (+) Winter;
- 40% (+) Spring.

Increase of *Cl. tyrobutyricum* in feces:
+2,4 Summer
+41,5 Winter
+99,7 Spring





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

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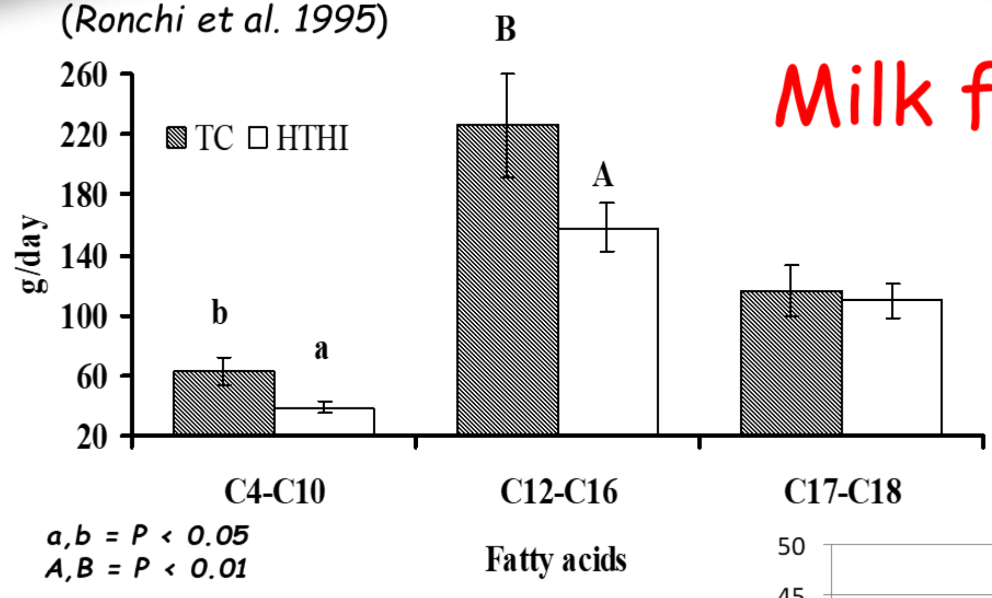
Table 4. Least square means of milk total coliform count, fecal coliform count, *E. coli* count, and *S. aureus* and *E. coli* isolation from milk of Frisian cows exposed to different temperature-humidity index (mxTHI)

	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] $p<0.001$.

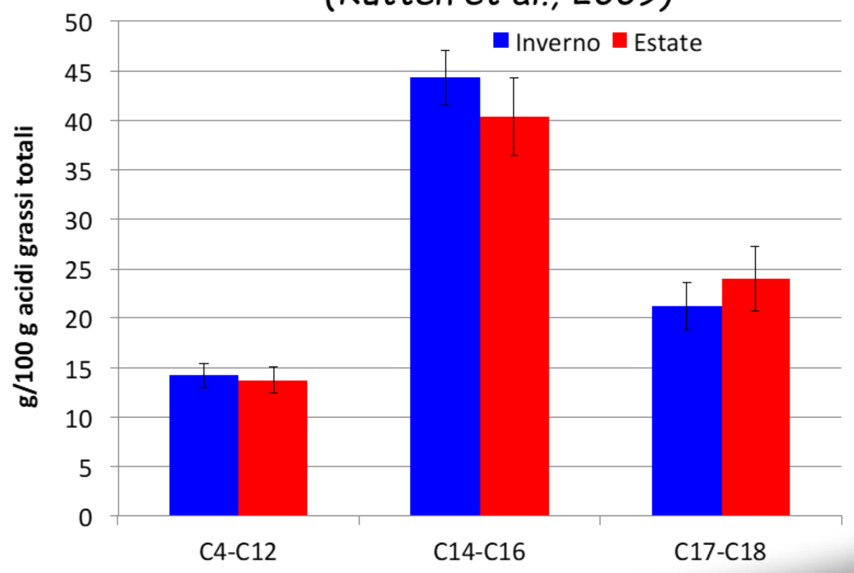
Milk fat composition

(*Ronchi et al. 1995*)



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

(*Rutten et al., 2009*)



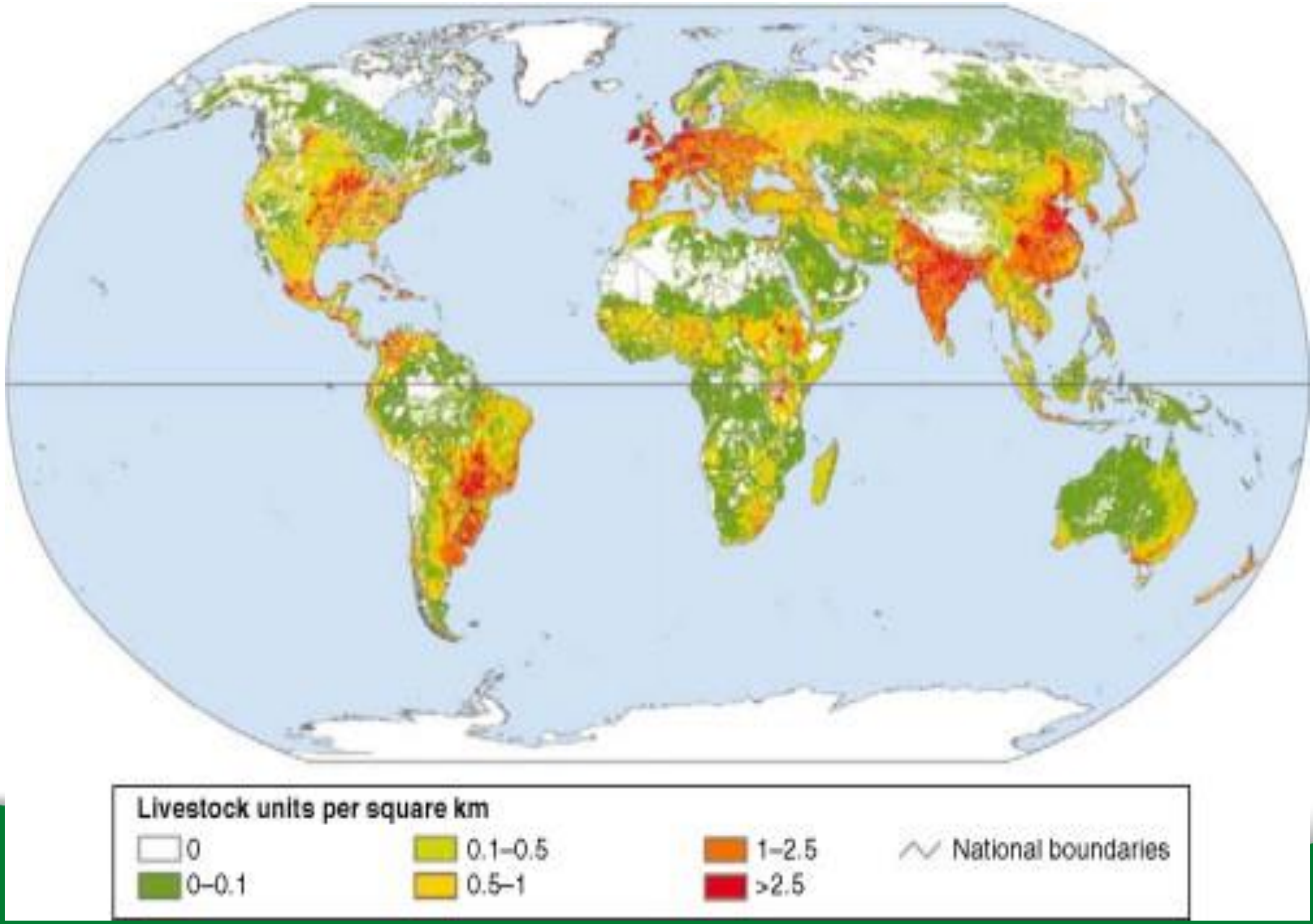
Livestock production systems and sustainability

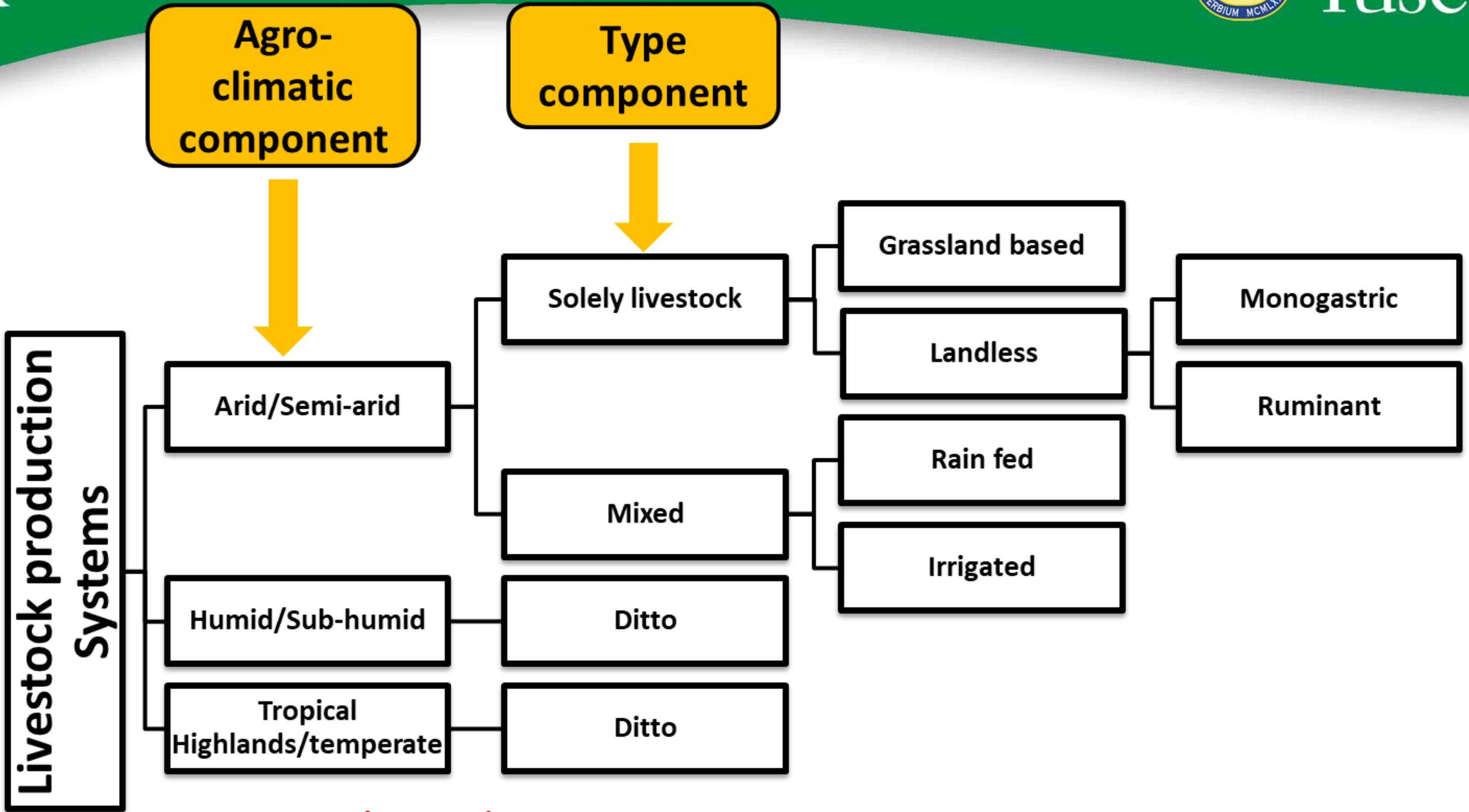
What do we mean when we talk about livestock production and what is the definition of livestock?

It is defined as domesticated animals raised in an agricultural production system with the aim of producing food, fibre and labour.

Sometimes, reference is only made to ruminants such as cattle, sheep and goats but this definition should include all livestock which fits the original description, including poultry, pigs etc.

Global density of livestock (units per square kilometre) (FAO, 2006b)





Livestock production systems

according to the classification devised by Seré and Steinfeld (1996). This classification system consists of two main criteria namely Agro-climatic and Type (Rust, 2019).

Farming systems

Principal categories :

Serè and Steinfeld, 1996; Steinfeld et al., 2006, 2006b (modified)

1. **Grazing/pastoral systems:** these include 3.35 billion hectares of arid pastures which are not cultivable. This system provides 24% of the production of beef and 30% of the production of sheep and goat meat *(Steinfeld et al., 2006).* Ruminants are the most represented species reared.

2. **Combined/mixed agro-zootechnical systems** (rainfed/irrigated): these are the most important systems of animal production for that which regards the number of animals, total production and the number of consumers supplied. These systems include nearly 2.5 billion hectares which represent the principle sources of meat (46%) and milk (90%). All species are represented.

3. **Industrial/landless systems** (monogastrics/ruminats): these systems provide the production of roughly 71% of the chicken and 55% of the pork produced worldwide. Monogastrics are the most represented species.

4. **Stratified systems** (a combination of the above)

Three questions regarding **climate change**

1st. Which livestock systems will be more affected by climate changes?

2nd. Which modifications are needed in the livestock systems to cope with the effects for maintaining sustainability?

3rd. Which livestock production factors will be the most vulnerable under climate changes?

The answer to the 1st question

To answer the 1st question we can divide the livestock systems into 3 main levels regarding **climate dependence**

Climate dependence/vulnerability of livestock systems

CLIMATE	SYSTEMS	
Totally dependent	Grazing/Pastoral	
Partially dependent	Mixed: Rainfed, Irrigated	
Potentially independent	Industrialized/Landless	

Dependence: how much the animal performances and health are affected by the climatic conditions

Nardone et al., 2010

Climate dependence/vulnerability of livestock systems

Totally dependent

Grazing/Pastoral systems: are systems where the animals are free or forced to graze, and don't have any protection from direct climatic effects. Animals can avoid solar radiation only by taking shelter in the shade of the trees, where and if there are any.

Partially dependent / Independent

Mixed and Industrialized systems: Animals are reared in barns where temperature, humidity, solar radiation, wind and so on, are totally or at a very high level under structural and managerial control.

Nardone et al., 2010

The answer to the 2nd question
on modification of systems

Pastoral systems: species, feeding and production

red - green + yellow =

	Small ruminant	Beef cattle	Dairy cattle	Pigs	Other
Pasture	↓	↓	↓	↓	↓
Defence to CC	↔	↔	↔	↔	↔
Animal health	↓	↓	↓	↓	↓→
Stock	↓→	↓→	↓	○	↑→
Production	↓→	↓	↓	○	↑→
Biodiversity	↓	↓	↓	↓	↔
Sustainability	↓	↓	↓	↓	↑→

Tomorrow

Africa; South America; South Asia; South Australia

Mixed rainfed systems: species, feeding and production

The possibility to cope with the effects of climate change will vary according to the available technologies and extension services where the systems are located.

	Dairy cattle	Beef cattle	Pigs	Poultry	Small ruminant	Other
Forages	↓→	↓→			↓	
On farm grain	↓	↓	↓	↓	↓	
Market grain	↑	↑	↑	↑	↑	
Defence to CC	↓→	↔	↔	↓→	↔	↔
Animal health	↓	↓	↓	↓	↓	↓→
Stock	↓	↔	↓→	↓	↓→	↑→
Production	↓→	↓→	↓→	↓	↔	↑→
Biodiversity	↓	↓	↓	↔	↓→	↔
Sustainability	↓	↓	↓	↓	↓→	↔

red - green + yellow =

Tomorrow

Central Europe; North America; Northern India; North-East China

Mixed irrigated systems: species, feeding and production

	Dairy cattle	Beef cattle	Pigs	Poultry	Small ruminant	Other
Stock						
Feeds: *Forage* *On farm grain* *Market grain*						
Production *Milk* *Meat*						

Modifications are possible according to the possibilities in irrigating and in adaptation of barns/houses

Industrialized livestock systems: stock, feeding, production

Tomorrow

	Dairy cattle	Beef cattle	Pigs	Poultry	Small ruminant	Other
Stock	↑	↑	⬆	⬆	↑	
On farm grain *Market grain*	↑	↑	↑	↑	↑	
Production *Meat* *Milk*	↑	↑	⬆	⬆	↑	

red - green + yellow =

The answer to the 3rd question
on factors more vulnerable

Climate change

risks of poor quality water

>salinisation (harder water)
>content of chemical contaminants (organic/inorganic)
>concentration of heavy metals
>concentration of biological contaminants

		i.e. impairments
>nitrites	→	**-cardiovascular system**
		-respiratory system
>heavy metal	→	**-escretory, skeletal and nervous system**
		-production (hygienically and sanitary Q.)
>altered pH	→	**-metabolism**
		-fertility
		-digestion

Global warming forces us to produce animal products that need less water

Protein content in % per Kg of product		g of product to obtain 1 unit of protein (= 34 g)	
		g of product	Kg water consumption
Beef	21	162	4577
Chicken	19	179	1342
Milk	3	1000	1500

	Sweat water/year (Km^3/year)
Total	110.300
Loss	97.800
Avalaible for man activity:	12.500
-agricult.	2880
-industrial	975
-towns	300
-other	275

Beef requires 3.4 times more water than poultry or milk to produce 1 unit of animal proteins

Summary of three answers

Regarding adaptation to climate change (CC)

- All livestock systems are affected by CC, (>pastoral, >rainfed mixed, <>irrigated mixed, <industrialized),
- Pastoral systems and ± mixed rainfed systems will face difficulties adapting to CC,
- Industrialized and ± mixed irrigated systems can cope with CC.
- Money and energy will be needed.

Regarding animal population

- Pigs and poultry will remarkably increase in number,
- Species and breeds tolerant to heat stress will increase in population, especially goats,
- Camels could be rediscovered.

Summary of three answers

Regarding production

- Pork, poultry and egg production will remarkably increase,
- Production dependent on crops and pastures will undergo inconveniences,
- Growth in production of meat from ruminants and cow milk will be restricted.

Regarding productive factors

- Water can be a very limiting factor for livestock.

Concluding remarks

- Heat stress affects in some ways metabolic and physiological acclimation of ruminants (especially dairy animals) and their health and productivity.

- The severity of heat stress is expected to increase in the future as global warming progresses and genetic selection for production continues.

Concluding remarks

- Improved knowledge of the functional relationship between animals and their environment, and of the physiological mechanisms of acclimation may contribute:
  - to the adoption of procedures that improve welfare and the efficiency of production and reproduction;
  - to develop novel approaches (i.e. genetic, managerial and nutritional) to maintain production or minimize the reduction during stressful summer months in high-producing farm animals.

Concluding remarks

Genetic and genomic differences within farm animals with respect to heat-tolerance may provide clues or tools to select productive and thermo-tolerant animals.

Concluding remarks

- The grazing and mixed rainfed systems, which count on the availability of pastures and on farm crops, will be most damaged by climate change.

- Consequences would be considerable, since these two systems raise almost 70% of all the ruminants in the world and (Worldwide) they produce almost 2/3 (two/thirds) of the milk and more than 70% of meat from ruminants.

- An aspect which makes the situation even more critical is that more than 50% of this production is raised in developing countries where the need of animal products will increase.

Concluding remarks

- Because of the foreseeable reduction in areas suitable for livestock and the limited availability of water, the number of heads of species reared in industrialized systems will increase. Therefore, we will have more pigs and poultry.

- In addition, because of the main difficulties in grazing and rainfed systems, we can predict an increase in production also of milk and beef in industrialized systems, even if this increase will be more moderate than poultry and pork.

The role of research

- Close collaboration between animal scientists and agronomists, meteorologists, engineers, economists and others
- Effort in selecting animals concentrating on robustness and adaptability to heat stress
- Avoid risk of inbreeding and loss of genetic variability
- Develop new technologies in controlling microclima with low energy expenditure
- Develop new indices to evaluate climatic effects on animals
- Develop ad hoc weather forecast-reports for animal species or production
- Improve technology of water conservation
- Select crops for harsh environment


Grazie per l'attenzione

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

	a_s-CN	b-CN	k-CN	a-La	b-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)

NORMAL - WELL FED