Factors affecting embryo temperature and their effects on chick quality

Sander.lourens@wur.nl
www.hatchability.com

LIVESTOCK RESEARCH WAGENINGEN UR

Colombia mevea

Sander Lourens

- 1996 MSc in Fisheries Biology & Aqua Culture
- 1997 Laboratory Salmonella & Campylobacter Plukon Poultry
- 1998 Center for Applied Poultry Research “Het Spelderholt”
- 2003 Researcher Poultry Production at Wageningen UR Livestock Research
- 2007 Researcher Healthy Chicks in Healthy Poultry Chains at WUR-LR
- 2008 PhD “embryo temperature during incubation: practise and theory”
- 2012 www.hatchability.com – a website to inspire hatchery workers

Recent projects:

- Reduction of antibiotics and ESBL in the Dutch Broiler Chain
- Optimising technical and financial results in all sectors in the broiler chain
- Food Security Project in Indonesia on broiler farming
- Pilot farms and hatchery development in India

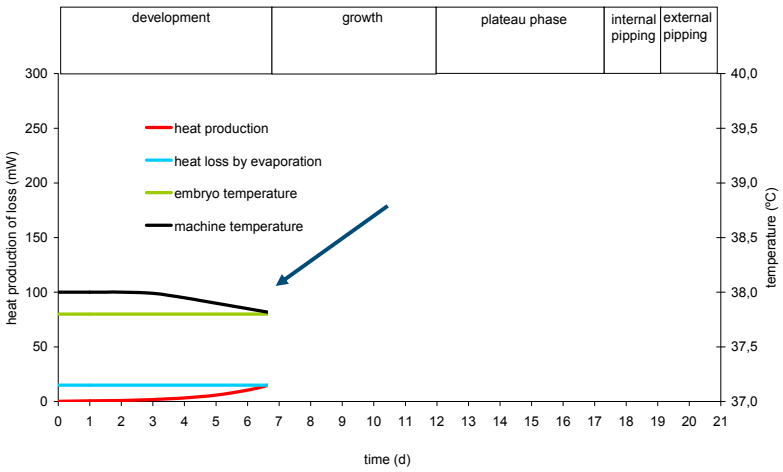
LIVESTOCK RESEARCH WAGENINGEN UR

Incubation for good chick quality

- Machine temperature ≠ embryo temperature
- Balance between heat loss and heat production (HP)
- Factors that affect heat loss
- Factors that affect HP
- Effects of uncontrolled embryo temperature

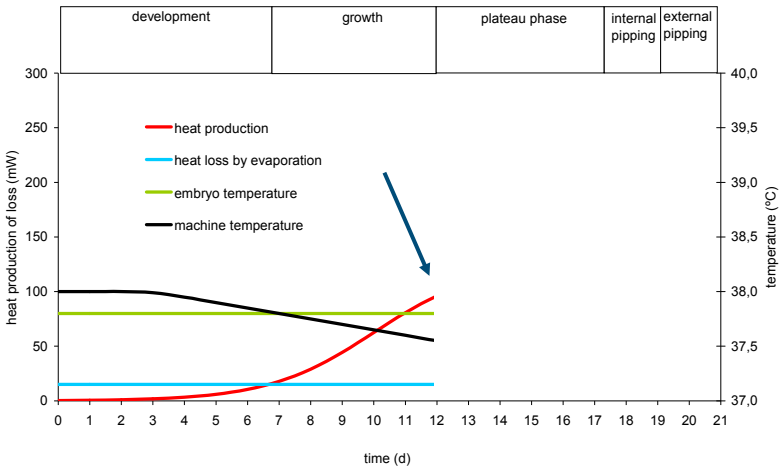
LIVESTOCK RESEARCH WAGENINGEN UR

Machine temperature ≠ embryo temperature



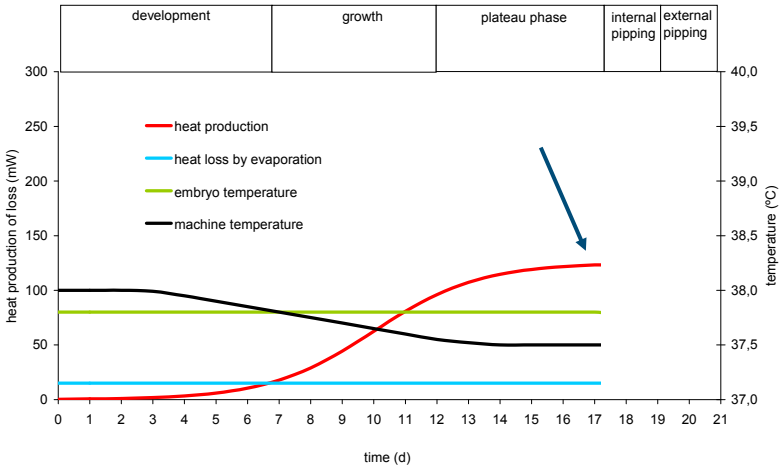
LIVESTOCK RESEARCH WAGENINGEN UR

Machine temperature ≠ embryo temperature



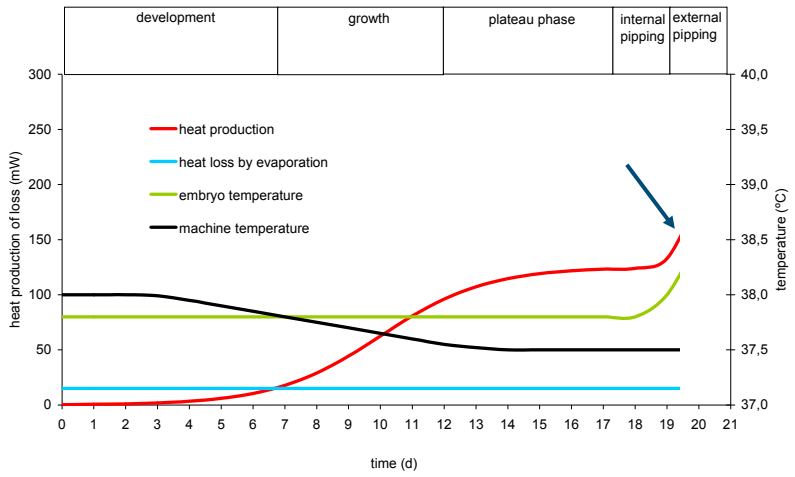
LIVESTOCK RESEARCH WAGENINGEN UR

Machine temperature ≠ embryo temperature



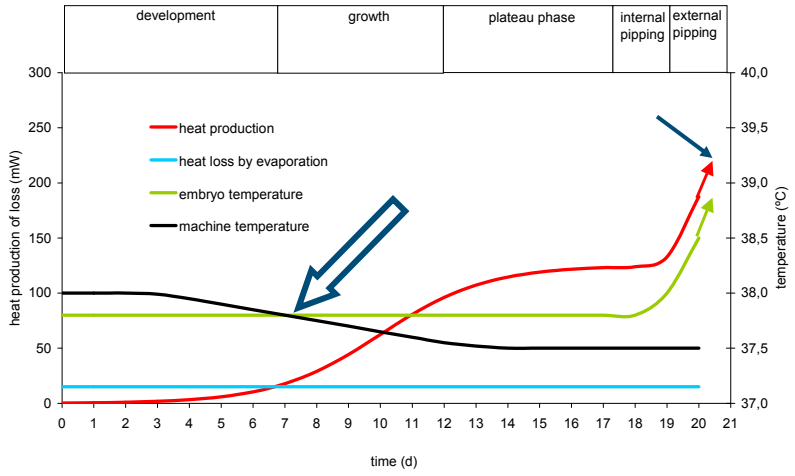
LIVESTOCK RESEARCH WAGENINGEN UR

Machine temperature ≠ embryo temperature

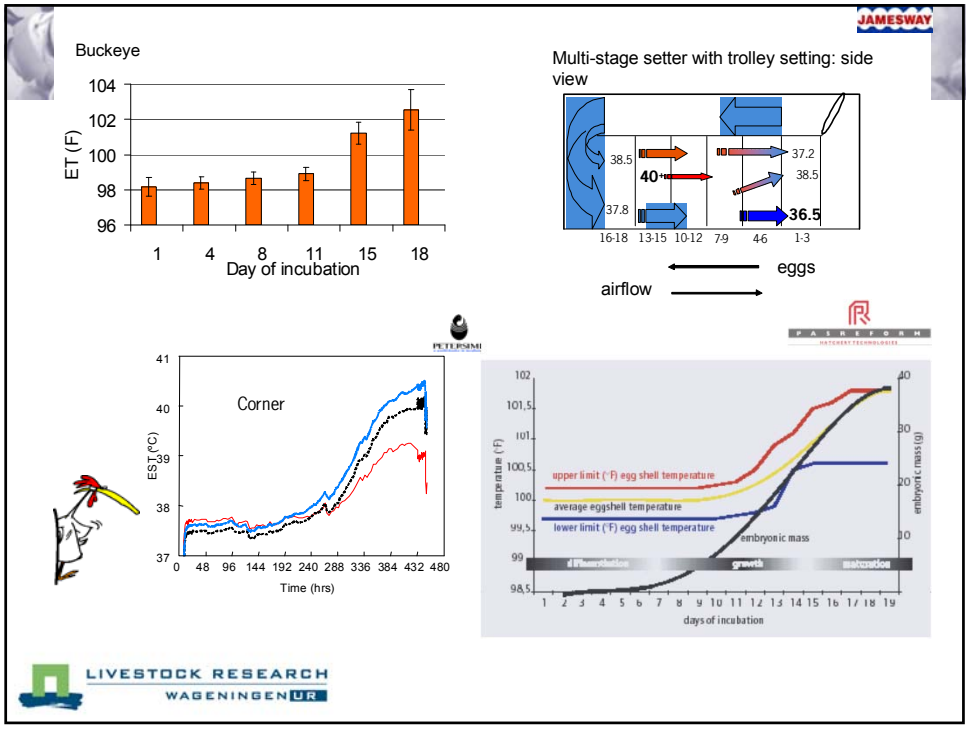


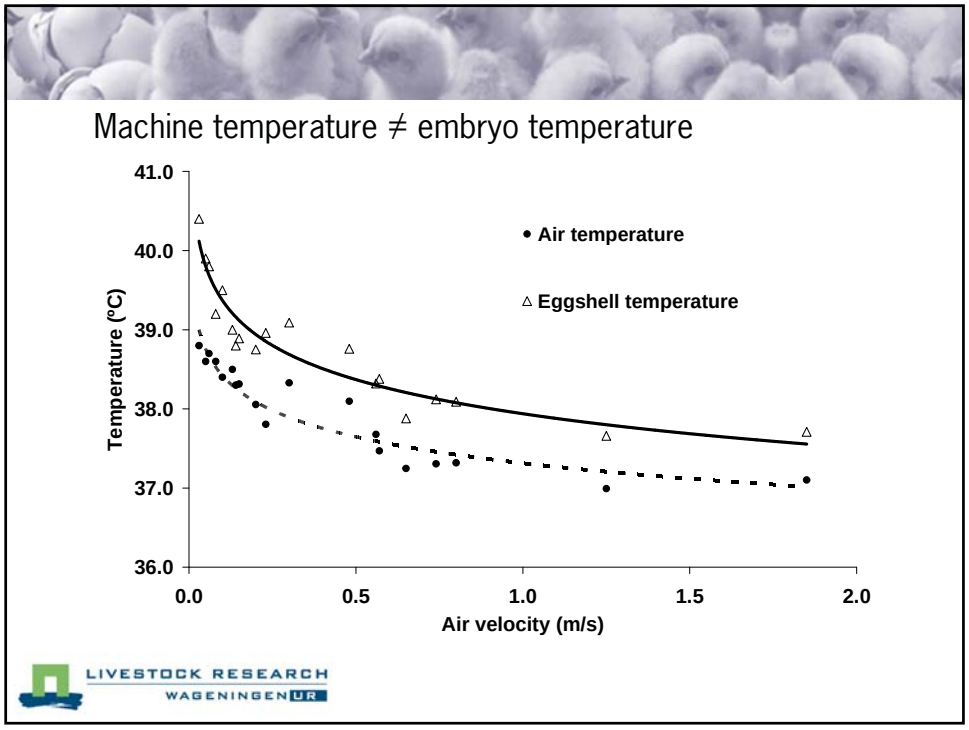
LIVESTOCK RESEARCH WAGENINGEN UR

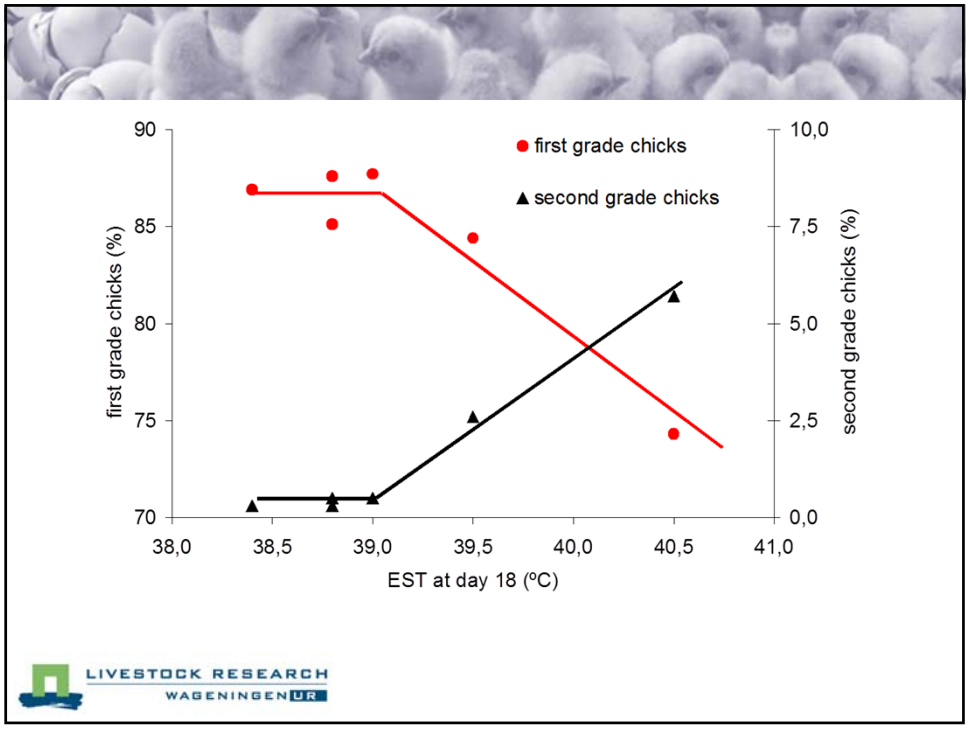
Machine temperature ≠ embryo temperature

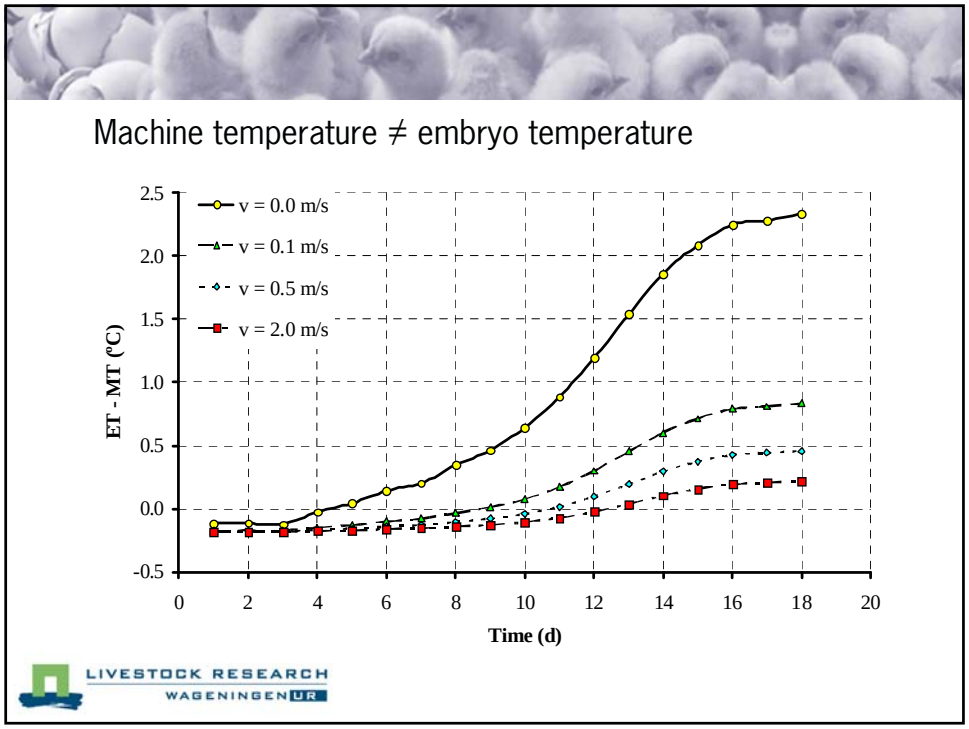


LIVESTOCK RESEARCH WAGENINGEN UR


Buckeye
ET (F)
104
102
100
98
96
1
4
8
11
15
18
Day of incubation
Multi-stage setter with trolley setting: side view
38.5
40
37.8
37.2
38.5
36.5
16-18
13-15
10-12
7-9
4-6
1-3
eggs
airflow
Corner
EST (°C)
41
40
39
38
37
0
48
96
144
192
240
288
336
384
432
480
Time (hrs)
upper limit (°F) egg shell temperature
average eggshell temperature
lower limit (°F) egg shell temperature
embryonic mass
temperature (°F)
embryonic mass (g)
days of incubation
LIVESTOCK RESEARCH
WAGENINGEN UR


Machine temperature ≠ embryo temperature
41.0
40.0
39.0
38.0
37.0
36.0
Temperature (°C)
0.0
0.5
1.0
1.5
2.0
Air velocity (m/s)
• Air temperature
△ Eggshell temperature
LIVESTOCK RESEARCH
WAGENINGEN UR


first grade chicks
second grade chicks
first grade chicks (%)
second grade chicks (%)
EST at day 18 (°C)
90
85
80
75
70
10,0
7,5
5,0
2,5
0,0
38,0
38,5
39,0
39,5
40,0
40,5
41,0
LIVESTOCK RESEARCH
WAGENINGEN UR

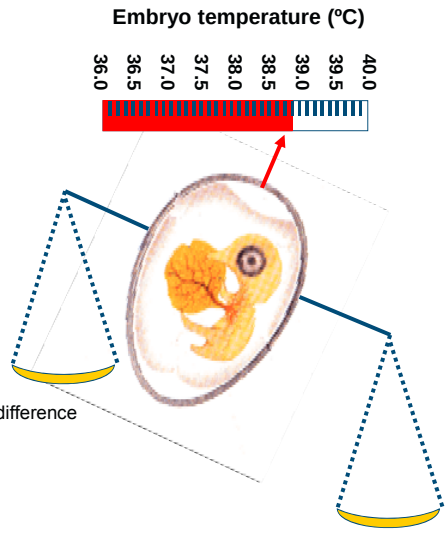

Machine temperature ≠ embryo temperature
v = 0.0 m/s
v = 0.1 m/s
v = 0.5 m/s
v = 2.0 m/s
ET - MT (°C)
Time (d)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
2
4
6
8
10
12
14
16
18
20
LIVESTOCK RESEARCH
WAGENINGEN UR

Machine temperature ≠ embryo temperature

- MT = ET only at 1 point, when heat loss = heat production
- timing depends on air velocity across the eggs
- differences between incubators
- differences between positions in the incubator

LIVESTOCK RESEARCH
WAGENINGEN UR

ET: balance between heat production and heat loss



Heat loss
- Evaporation
- Heat transfer
  - temperature difference
  - heat capacity
  - air velocity

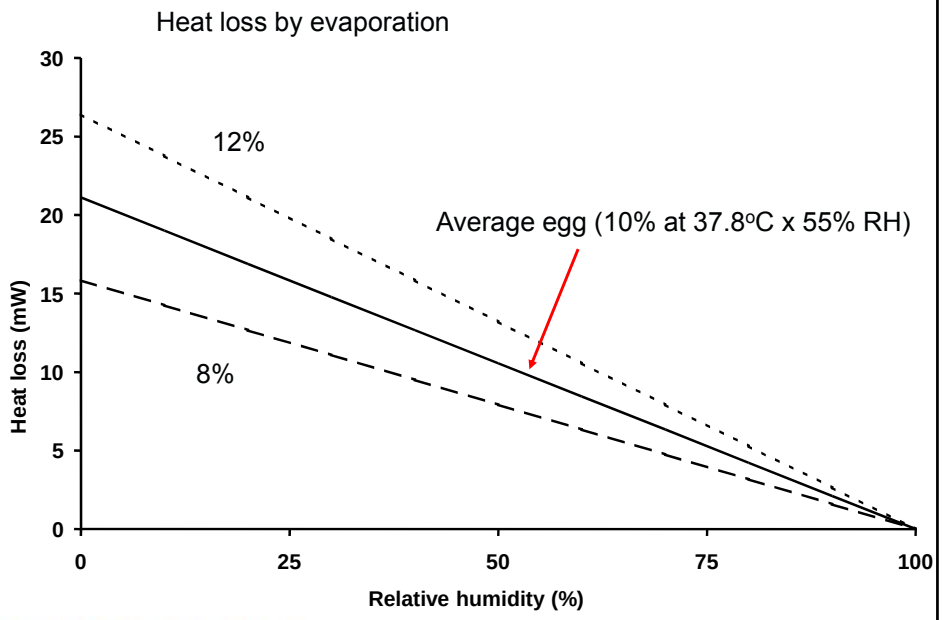
Heat production
- Time / development
- Physical factors
- Biological factors
- Environmental factors

1. Factors that affect heat loss

2 components that determine heat loss:

- Evaporation (latent HP)
  - *relative humidity and air temperature*
  - *eggshell quality*
- Heat transfer
  - *temperature difference between egg and environment*
  - *heat capacity of air (relative humidity)*
  - *air velocity*

LIVESTOCK RESEARCH WAGENINGEN UR



LIVESTOCK RESEARCH WAGENINGEN UR

Heat loss: evaporation

- Weight loss: 10.000 eggs of 60 g loose 0.6% of initial weight per day
  - *Eggs incubated at 37.5ºC MT and 55% RH*
  - *Total weight loss: 150 ml water per hour*
  - *ET is decreased by 0.2ºC*
  - *Uniform at all places in the incubator*

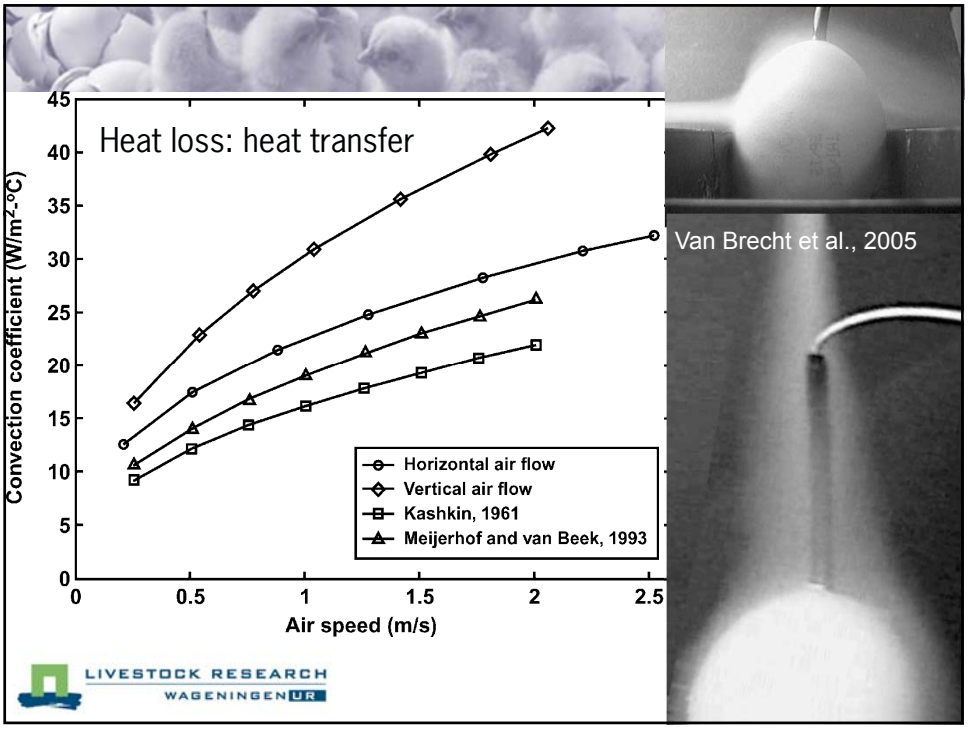
LIVESTOCK RESEARCH WAGENINGEN UR

Heat loss: evaporation

- Weight loss: 10.000 eggs of 60 g loose 0.6% of initial weight per day
  - *Eggs incubated at 37.5ºC and 55% RH*
  - *Total weight loss: 150 ml water per hour*
  - *ET is decreased by 0.2ºC*
  - *Uniform at all places in the incubator*
- Spray nozzles or humidifying discs:
  - *Local cooling effects*
  - *150 ml water per hour at 10% of the eggs: ET is decreased by 2.0ºC!*

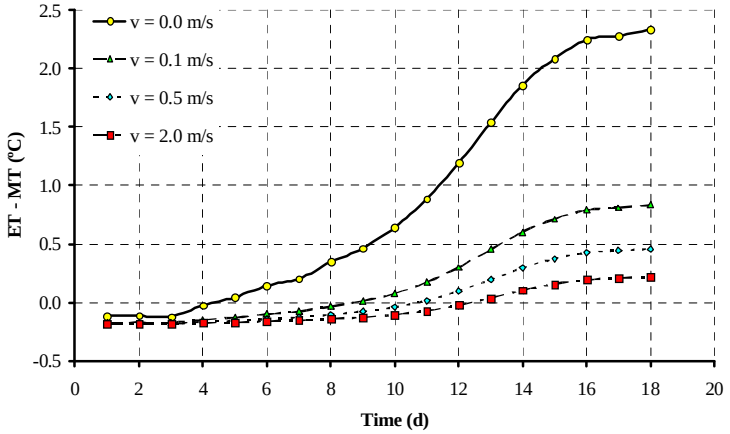
LIVESTOCK RESEARCH WAGENINGEN UR

Heat loss: heat transfer



LIVESTOCK RESEARCH WAGENINGEN UR

Heat loss: heat transfer

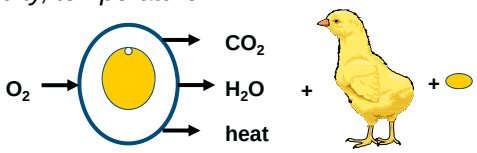


Calculated for eggs incubated at the same MT

LIVESTOCK RESEARCH WAGENINGEN UR

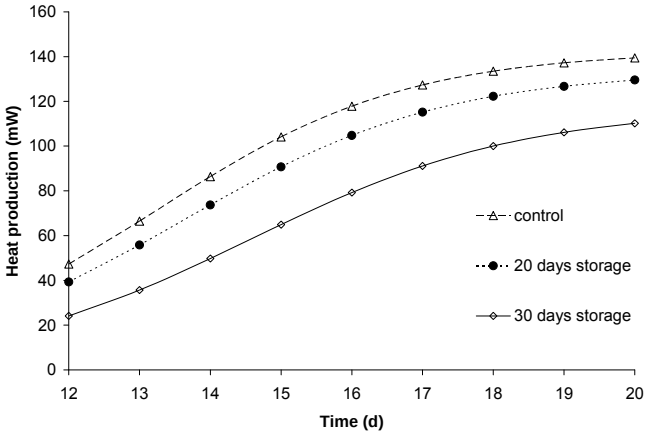
2. Factors that affect heat production

- Age of the embryo (time)
- Physical factors
  - *storage conditions, egg turning*
- Biological factors
  - *egg size, breed, breed age*
- Environmental factors
  - *oxygen, carbon dioxide, humidity, temperature*



LIVESTOCK RESEARCH WAGENINGEN UR

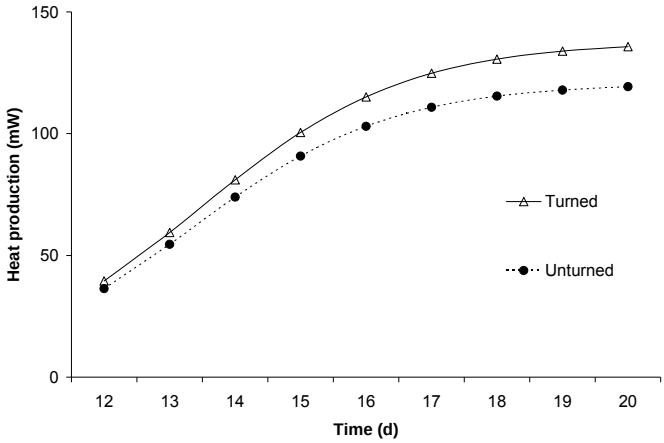
Physical factors: egg storage



Hague et al., 1996

LIVESTOCK RESEARCH WAGENINGEN UR

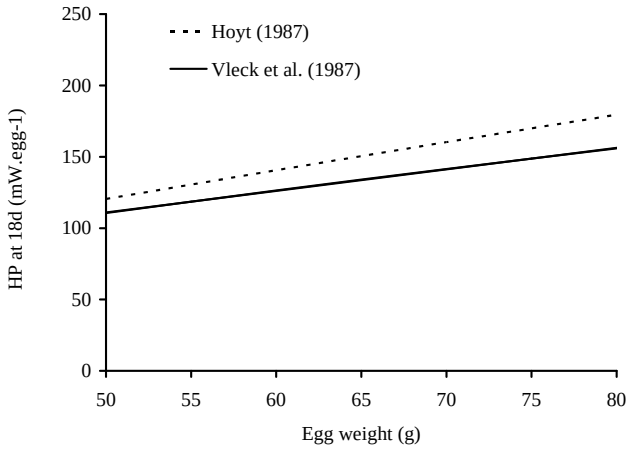
Physical factors: egg turning



Pearson et al., 1996

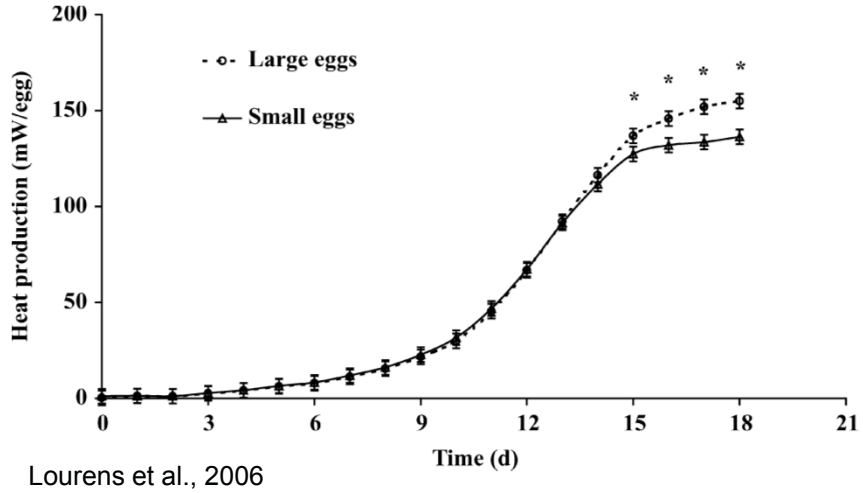
LIVESTOCK RESEARCH
WAGENINGEN UR

Biological factors: egg size



LIVESTOCK RESEARCH
WAGENINGEN UR

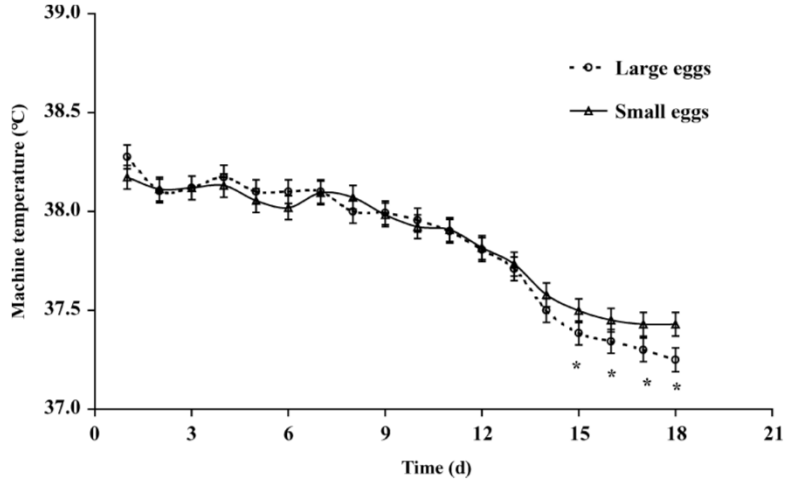
Biological factors: egg size



Lourens et al., 2006

LIVESTOCK RESEARCH WAGENINGEN UR

Biological factors: egg size



Lourens et al., 2006

LIVESTOCK RESEARCH WAGENINGEN UR

Biological factors: breed

Metabolic heat production (mW per egg)

d	R308*	R508*	Layer*	Traditional**
17	151	160	133	130
18	156	149	130	137
19	164	161	127	124
20	252	239	131	169

*Janke, Tzschenktke and Boerjan (2004)

** Romijn and Lokhorst (1960)

LIVESTOCK RESEARCH WAGENINGEN UR

Differences between lines, genetic background

- Not much “hard” information
  - Mainly focus on layers vs broilers
- But practical experience:
  - Vedette, AA
  - Ross 308, hubbard classic, Hybro PN
  - Ross 508,
  - Ross 708, cobb 500, Hybro G+, Hubbard HY
  - Cobb 700, male lines

easy

difficult

LIVESTOCK RESEARCH WAGENINGEN UR

- General trend:
  - More meat yield ⇨ higher heat production
  - Better shell quality ⇨ more sensitive for heat

If people change breed, look where they come from

- Ross to Cobb: possible problems
- R508 to R308: more easy
- Cobb 500 to Cobb 700: be aware
  - 0.5 to 1ºF higher embryo temperature at same setting
  - 6-12 hours earlier hatch
  - More chick quality issues if temperature not adjusted

LIVESTOCK RESEARCH WAGENINGEN UR

Biological factors: breed

- Broiler and layer hatching eggs incubated at the same constant MT
- Differences in egg size
- Eggshell temperature at d18 for layer eggs: 38.3ºC
- Eggshell temperature for broiler eggs: 0,6 – 0,8ºC higher
  - metabolic rate higher
  - HP and ET are linearly related
  - oxygen conductance in broiler eggs higher? (poor eggshell quality?)
  - Broiler embryos contain and utilize more energy?
  - Efficiency of energy utilization??

LIVESTOCK RESEARCH WAGENINGEN UR

- Experiment with broiler hatching eggs (Lourens et al., 2007):
  - Eggs of similar size: 60 – 65g
  - EST between d8 – d19: 37.8ºC or 38.9ºC
  - O2: 17%, 21% or 25%

LIVESTOCK RESEARCH WAGENINGEN UR

Climate Respiration Chamber (CRC)

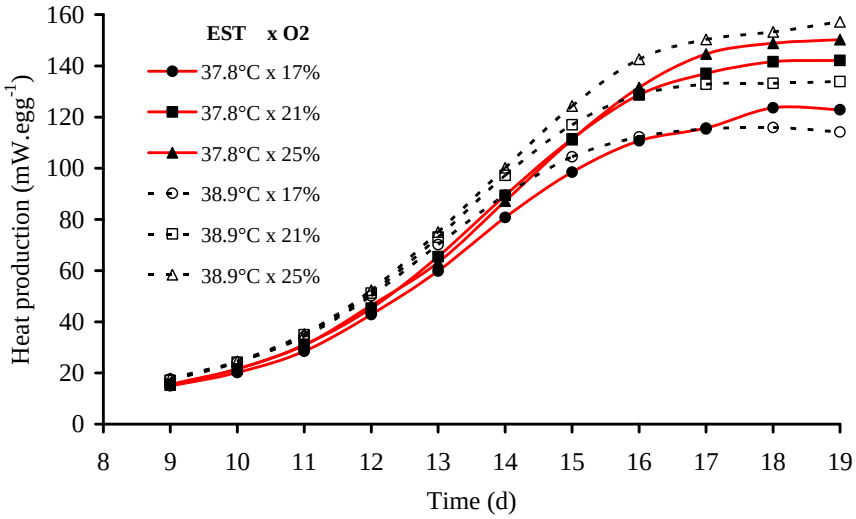
LIVESTOCK RESEARCH WAGENINGEN UR

LIVESTOCK RESEARCH WAGENINGEN UR

Control Room

LIVESTOCK RESEARCH WAGENINGEN UR

Source of variation	9	10	11	12	13	14	15	16	17	18	19
EST	*	*	*	**	**	**	*	-	-	-	-
O2	-	-	-	-	-	*	**	**	**	**	**
EST x O2	-	-	-	-	-	-	-	-	-	*	*



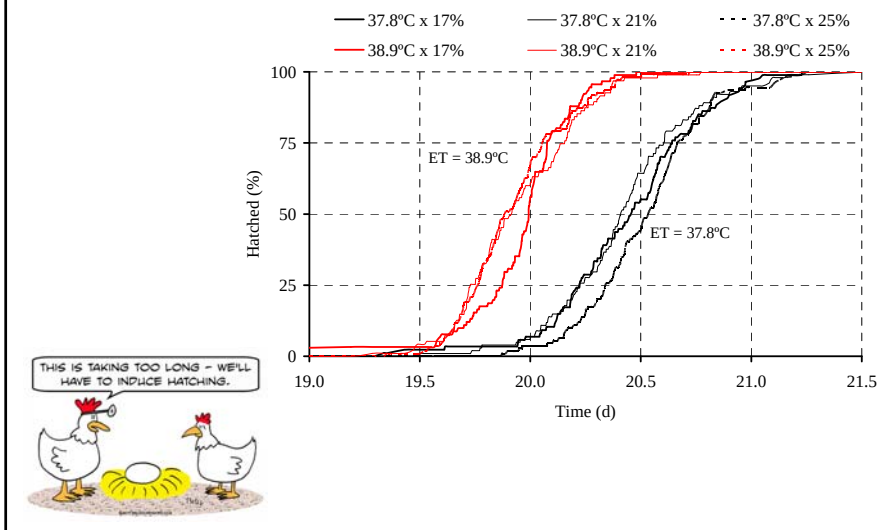
	CL (cm)	BW (g)	YFB (g)	RY (g)	HW (g)	LW (g)	HT (d)
EST							
37.8°C	19.7	41.5[a]	37.4[a]	4.0	0.40[a]	1.65[a]	20.5[a]
38.9°C	19.8	39.8[b]	35.8[b]	4.0	0.33[b]	1.53[b]	19.8[b]

LIVESTOCK RESEARCH
WAGENINGEN UR

	CL (cm)	BW (g)	YFB (g)	RY (g)	HW (g)	LW (g)	HT (d)
EST							
37.8°C	19.7	41.5[a]	37.4[a]	4.0	0.40[a]	1.65[a]	20.5[a]
38.9°C	19.8	39.8[b]	35.8[b]	4.0	0.33[b]	1.53[b]	19.8[b]
O2							
17%	19.0[c]	40.6	35.3[b]	5.3[a]	0.36	1.49	20.2
21%	19.9[b]	40.6	36.9[a]	3.7[b]	0.35	1.63	20.2
25%	20.4[a]	40.7	37.7[a]	3.0[c]	0.38	1.65	20.2

No interactions

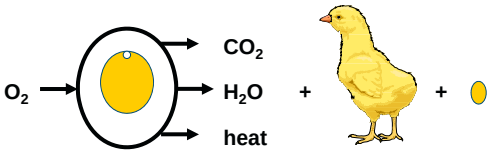
LIVESTOCK RESEARCH WAGENINGEN UR



LIVESTOCK RESEARCH WAGENINGEN UR

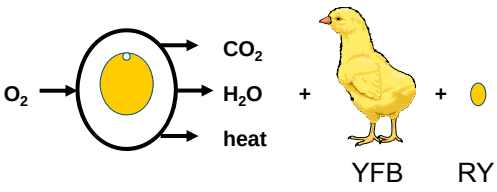
In general,

- For eggs of the same size, hatch time decreased when flock age increased
- Increased oxygen conductance in eggs of older flocks increased HP
- As a result, ET increased as well, which decreased hatch time!!
- What factor determines HP?
  - Energy utilization
  - Efficiency



LIVESTOCK RESEARCH WAGENINGEN UR

$$E_{\text{YFB}} = \frac{YFB(kJ)}{Albumen\,(kJ) + Yolk\,(kJ) - RY\,(kJ)}\ \text{x}100\%$$



LIVESTOCK RESEARCH WAGENINGEN UR

	EST		O_2		
	37.8°C	38.9°C	17%	21%	25%
Albumen (kJ)	73	76	73	75	76
Yolk (kJ)	280	282	282	281	281
YFB (kJ)	170^{a}	158^{b}	150^{b}	172^{a}	171^{a}
RY (kJ)	48	46	68^{a}	43^{b}	31^{c}
Utilized (kJ)	305	311	286^{c}	313^{b}	326^{a}
E_{YFB} (%)	55.7^{a}	50.8^{b}	52.5	54.9	52.4
HP at d18 (mW.egg^{-1})	131^{b}	148^{a}	119^{c}	138^{b}	152^{a}

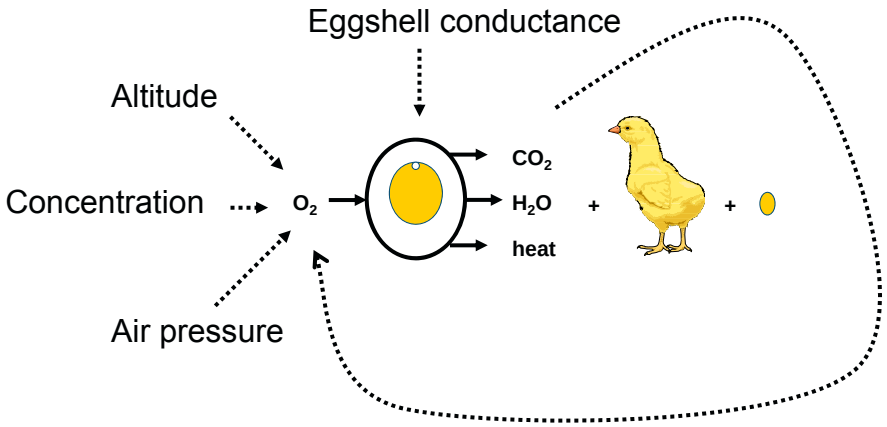
After Lourens et al. (2011).

LIVESTOCK RESEARCH WAGENINGEN UR

	Energy utilization	E_{YFB}
Egg weight	Yes	No
Breed	Yes	No
Oxygen	Yes	No
Eggshell temperature	No	Yes

LIVESTOCK RESEARCH WAGENINGEN UR

Environmental factors



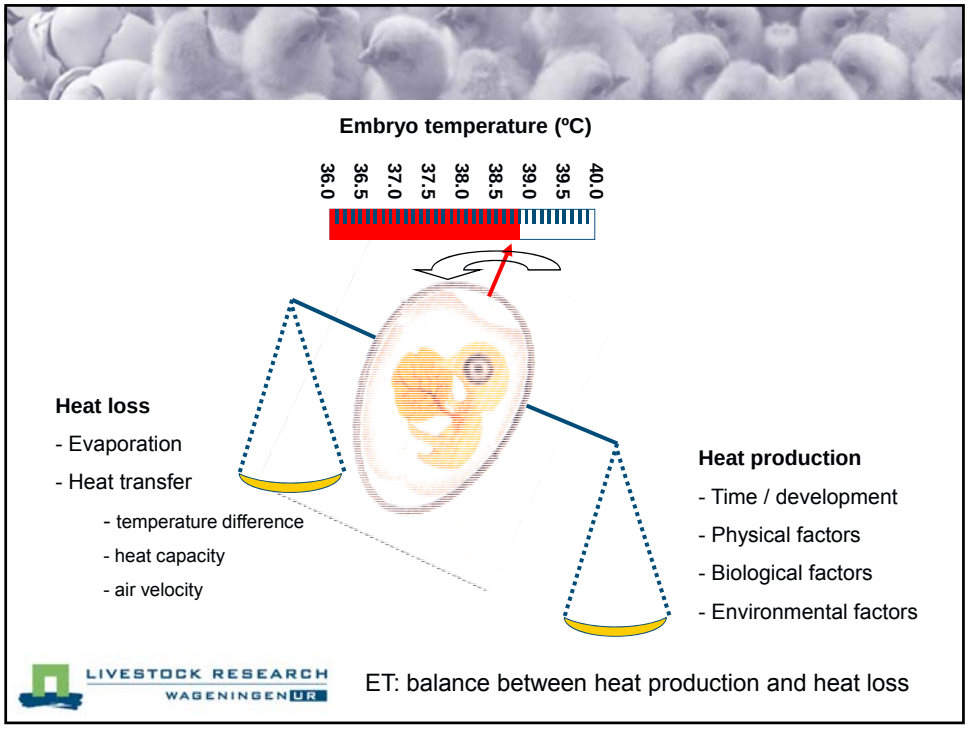
Oxygen availability to the embryo (red blood cells)

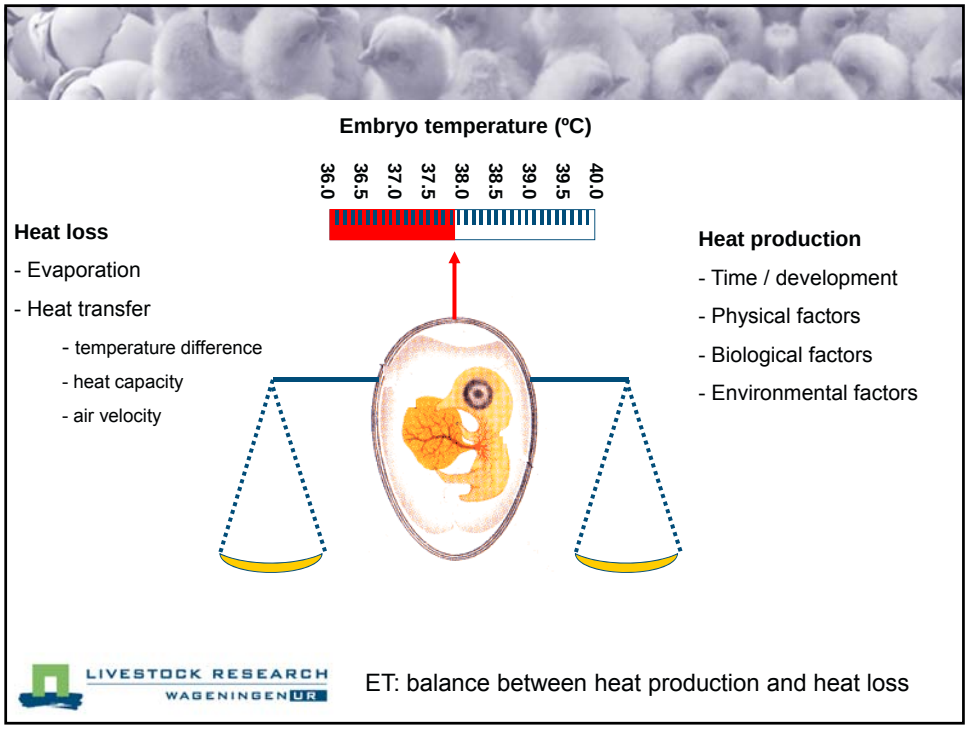
LIVESTOCK RESEARCH WAGENINGEN UR

Environmental factors: H_2O

- RH, MT, and conductance determine weight loss during incubation
- Development of air cell, required for internal pipping
- But focus on ET first…
- Ventilation early in incubation removes water from the machine
  - Not required
  - Creates cold spots
  - Spray nozzles / humidifiers to add moisture
  - High CO_2 level during week 1 stimulates development of membranes to support gas exchange later in week 3
  - High RH during week 1 needs to be compensated later

LIVESTOCK RESEARCH WAGENINGEN UR


Embryo temperature (ºC)
36.0 36.5 37.0 37.5 38.0 38.5 39.0 39.5 40.0
Heat loss
- Evaporation
- Heat transfer
- temperature difference
- heat capacity
- air velocity
Heat production
- Time / development
- Physical factors
- Biological factors
- Environmental factors
LIVESTOCK RESEARCH
WAGENINGEN UR
ET: balance between heat production and heat loss


Embryo temperature (ºC)
36.0 36.5 37.0 37.5 38.0 38.5 39.0 39.5 40.0
Heat loss
- Evaporation
- Heat transfer
- temperature difference
- heat capacity
- air velocity
Heat production
- Time / development
- Physical factors
- Biological factors
- Environmental factors
LIVESTOCK RESEARCH
WAGENINGEN UR
ET: balance between heat production and heat loss

Treatment	1-7 days	7-14 days	14-21 days
	98	100	100
"multi-stage"	98	100	102
"single-stage"	100	100	100
	100	100	102

temperature values are egg shell temperatures

LIVESTOCK RESEARCH WAGENINGEN UR

Lourens et al, 2005

value	YFBM (g)	Length (cm)	%hatch	7 d b.w. (g)	Heart (g)
98-100-100	37.1b	19.0ab	78.9a	147.7a	0.33ab
98-100-102	33.8a	18.3a	77.8a	148.0a	0.28a
100-100-100	37.9b	19.4b	84.7b	154.6b	0.36b
100-100-102	38.0b	19.3b	77.6a	151.9ab	0.31ab

LIVESTOCK RESEARCH WAGENINGEN UR

Take home message:

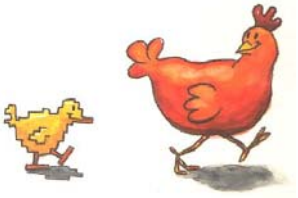
Eggshell temperature is the key!!!

To know EST, you have to measure it

Keep EST close to 37.8ºC constantly

LIVESTOCK RESEARCH
WAGENINGEN UR

Thanks for your attention!!



LIVESTOCK RESEARCH
WAGENINGEN UR