Factors affecting embryo temperature and their effects on chick quality

胚胎温度的影响因素，及其对雏鸡质量的影响

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Sander Lourens 个人简介

- 1996 MSc in Fisheries Biology & Aqua Culture
  获得渔业生物学与水产养殖 硕士学位
- 1997 Laboratory Salmonella & Campylobacter Plukon Poultry
  就职于Plukon禽类沙门氏菌与弯曲杆菌实验室
- 1998 Center for Applied Poultry Research "Het Spelderholt"
  就职于"Het Spelderholt"禽类应用技术研究中心
- 2003 Researcher Poultry Production at Wageningen UR Livestock Research
  瓦赫宁根大学及研究中心 畜牧科学研究院 禽类生产专业 研究员
- 2007 Researcher Healthy Chicks in Healthy Poultry Chains at WUR-LR
  瓦赫宁根大学及研究中心 畜牧科学研究院 禽业产业链上的雏鸡健康专业 研究员
- 2008 PhD "embryo temperature during incubation: practise and theory"
  获得博士学位，选题：孵化时的胚胎温度管理——理论与实践研究
- 2012 www.hatchability.com – a website to inspire hatchery workers
  创立专门服务于禽类孵化员的网站：www.hatchability.com

Recent projects: 近期的项目：

- Reduction of antibiotics and ESBL in the Dutch Broiler Chain
  降低荷兰肉鸡产业链抗生素与超广谱β内酰胺酶ESBL的用量
- Optimising technical and financial results in all sectors in the broiler chain
  优化肉鸡产业链各个环节的技术与财务状况
- Food Security Project in Indonesia on broiler farming
  印度尼西亚肉鸡养殖场的『粮食安全』相关项目
- Pilot farms and hatchery development in India
  印度的试点养殖场与孵化研发项目

Short video

longer video

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Incubation for good chick quality

孵化出高质量的雏鸡

- Machine temperature ≠ embryo temperature

  孵化器内的温度 ≠ 胚胎温度
- Balance between heat loss and heat production (HP)

  产热与散热的平衡
- Factors that affect heat loss

  影响散热的因素
- Factors that affect HP

  影响产热的因素
- Effects of uncontrolled embryo temperature

  不控制胚胎温度的影响

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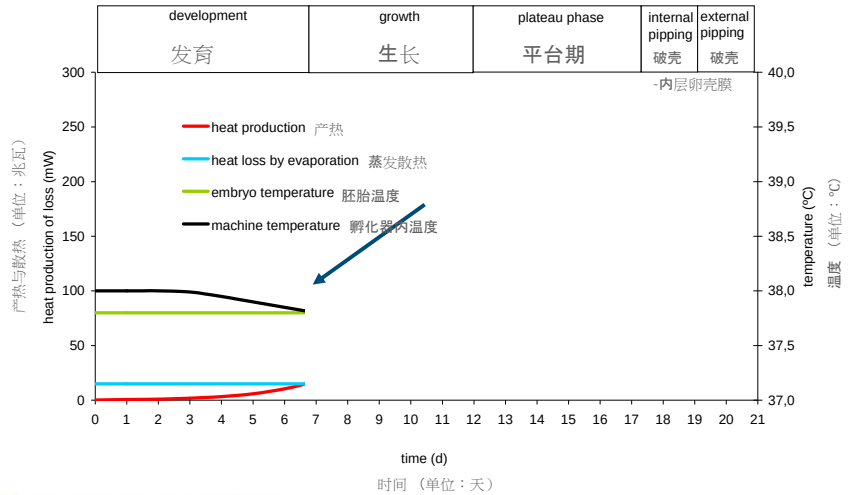
Machine temperature ≠ embryo temperature
孵化器内的温度 ≠ 胚胎温度



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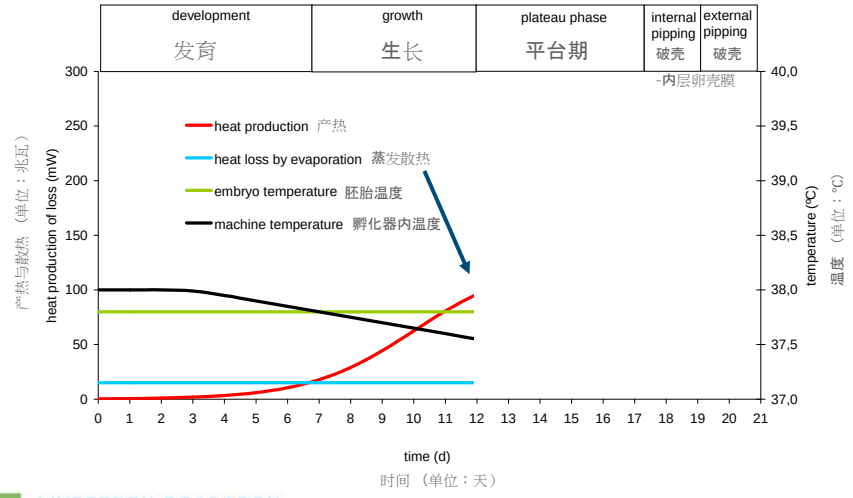

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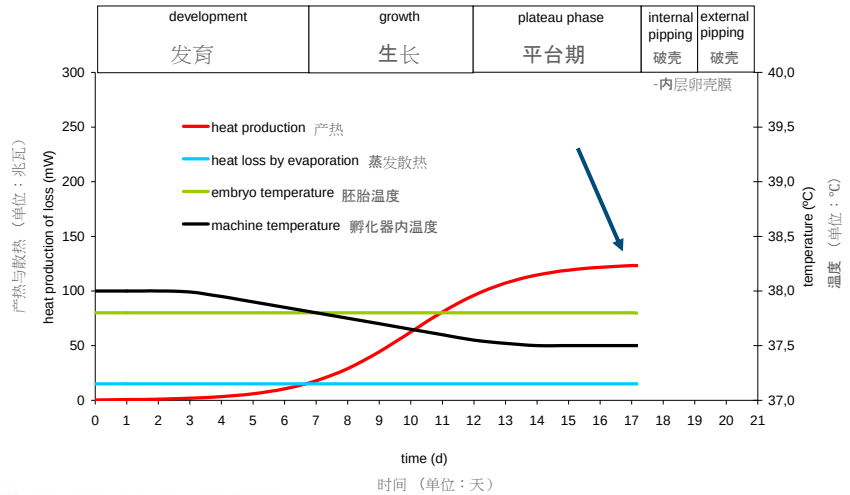

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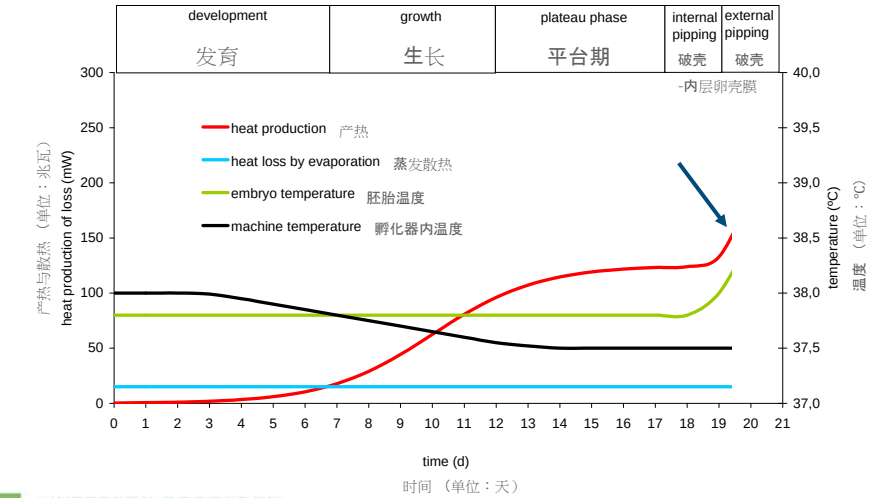

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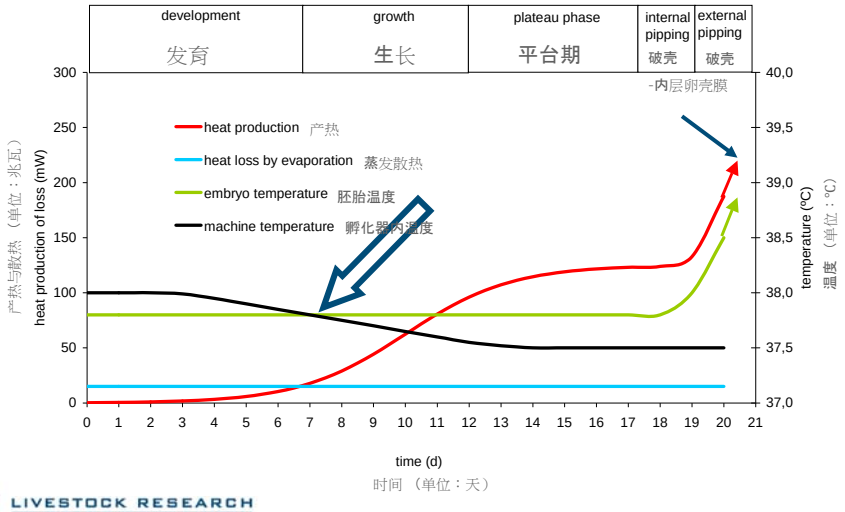

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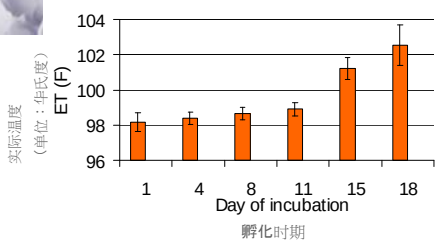
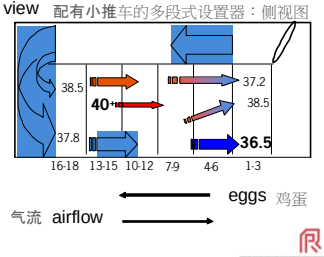
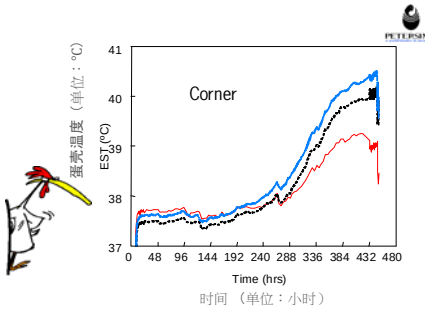
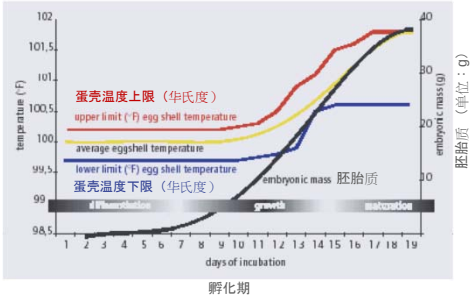
Buckeye 英国Buckeye公司



Multi-stage setter with trolley setting: side view 配有小推车的多段式设置器：侧视图







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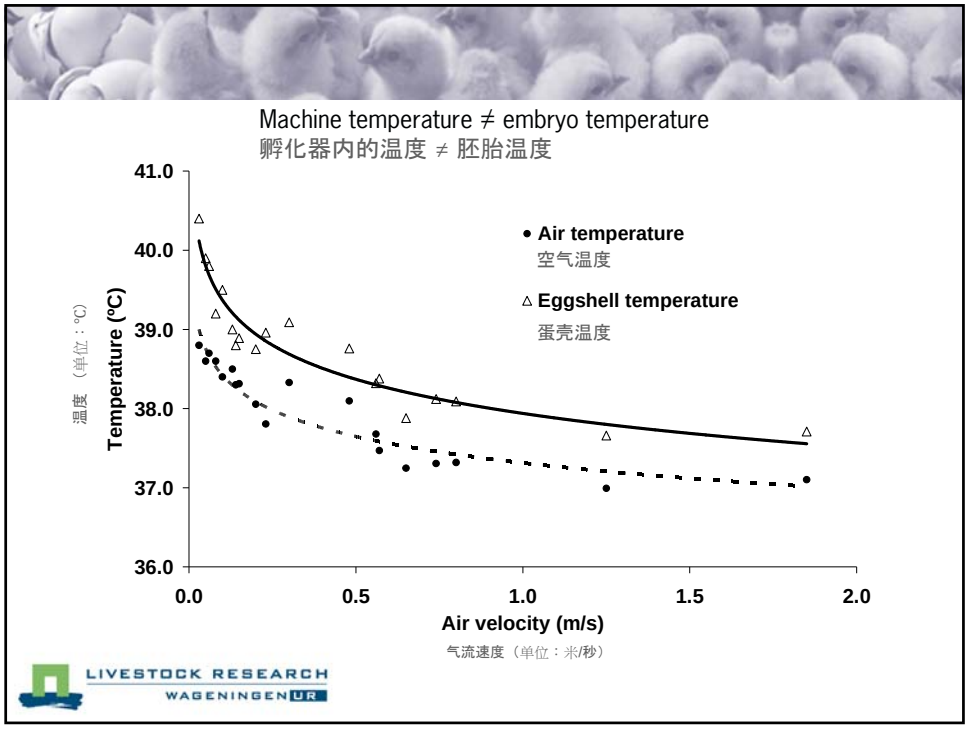
Machine temperature ≠ embryo temperature
孵化器内的温度 ≠ 胚胎温度
41.0
40.0
39.0
38.0
37.0
36.0
Temperature (ºC)
温度（单位：℃）
0.0
0.5
1.0
1.5
2.0
Air velocity (m/s)
气流速度（单位：米/秒）
• Air temperature
空气温度
△ Eggshell temperature
蛋壳温度
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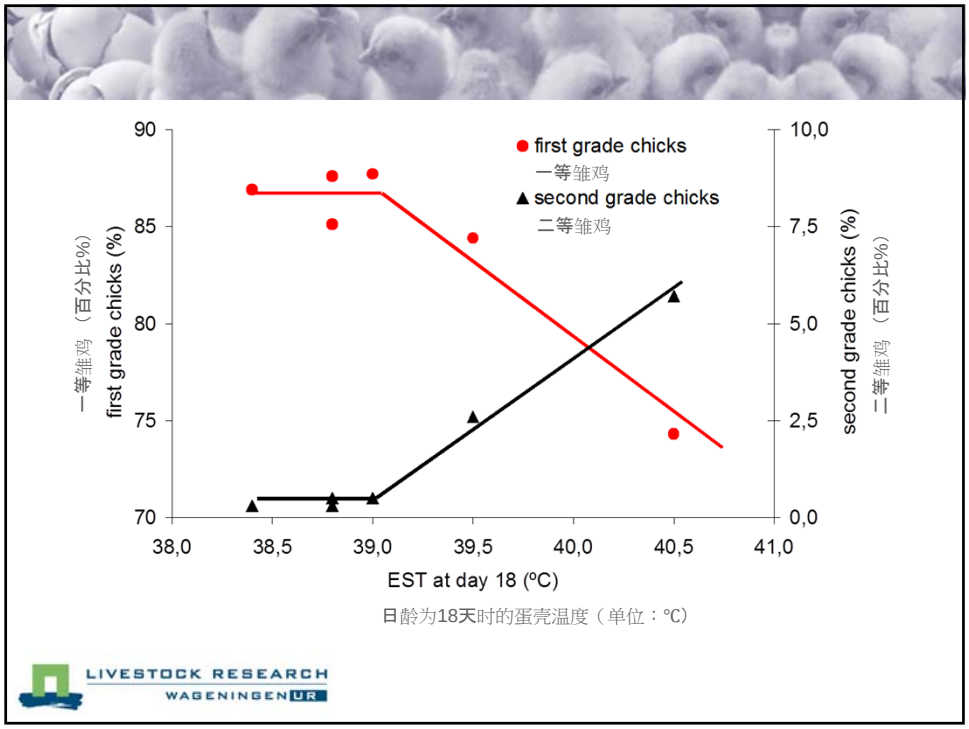
90
85
80
75
70
first grade chicks (%)
一等雏鸡（百分比%）
10,0
7,5
5,0
2,5
0,0
second grade chicks (%)
二等雏鸡（百分比%）
38,0
38,5
39,0
39,5
40,0
40,5
41,0
EST at day 18 (ºC)
日龄为18天时的蛋壳温度（单位：℃）
first grade chicks
一等雏鸡
second grade chicks
二等雏鸡
LIVESTOCK RESEARCH
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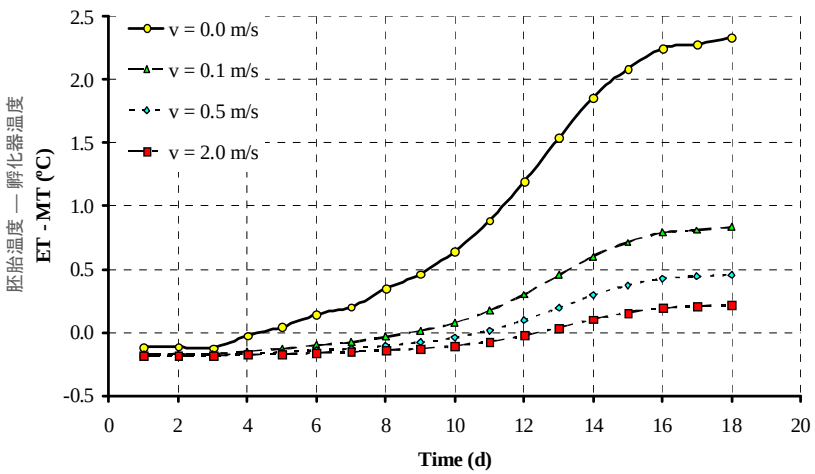
Machine temperature ≠ embryo temperature
孵化器内的温度 ≠ 胚胎温度



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Machine temperature ≠ embryo temperature
孵化器内的温度 ≠ 胚胎温度

- MT = ET only at 1 point, when heat loss = heat production

  只有在某一特定时间点，MT（孵化器温度）=ET（胚胎温度），此时热量产生=热量损耗
- timing depends on air velocity across the eggs

  时间点取决于鸡蛋周围的空气流通程度
- differences between incubators

  不同孵化器情况
- differences between positions in the incubator

  在孵化器中不同位置的差别

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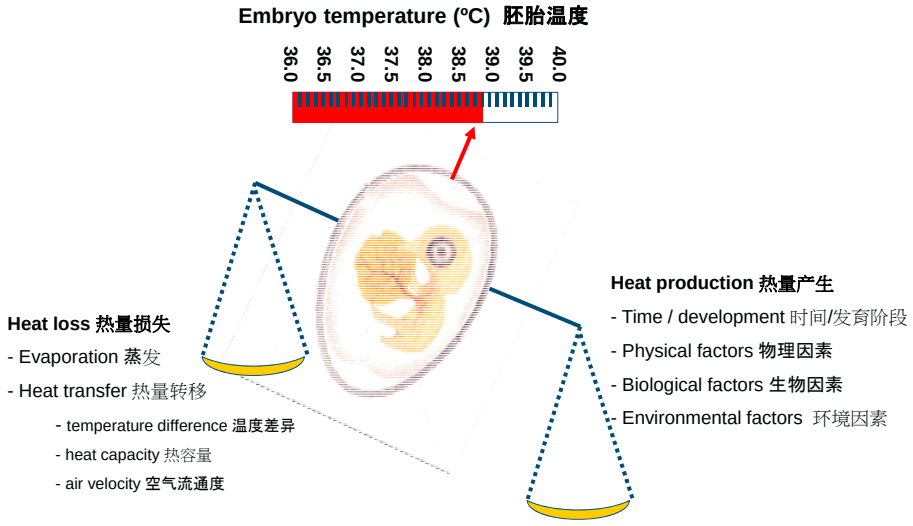
ET: balance between heat production and heat loss

胚胎温度：热量产生与热量损失之间的差异



1. Factors that affect heat loss 影响热量损失的因素

2 components that determine heat loss: 决定热量损失的两个因素

- Evaporation (latent HP) 蒸发
  - *relative humidity and air temperature 相对湿度与空气温度*
  - *eggshell quality 蛋壳质量*
- Heat transfer 热量转移
  - *temperature difference between egg and environment*
    鸡蛋与环境的温度差
  - *heat capacity of air (relative humidity) 空气的热容量（相对湿度）*
  - *air velocity 空气流动度*

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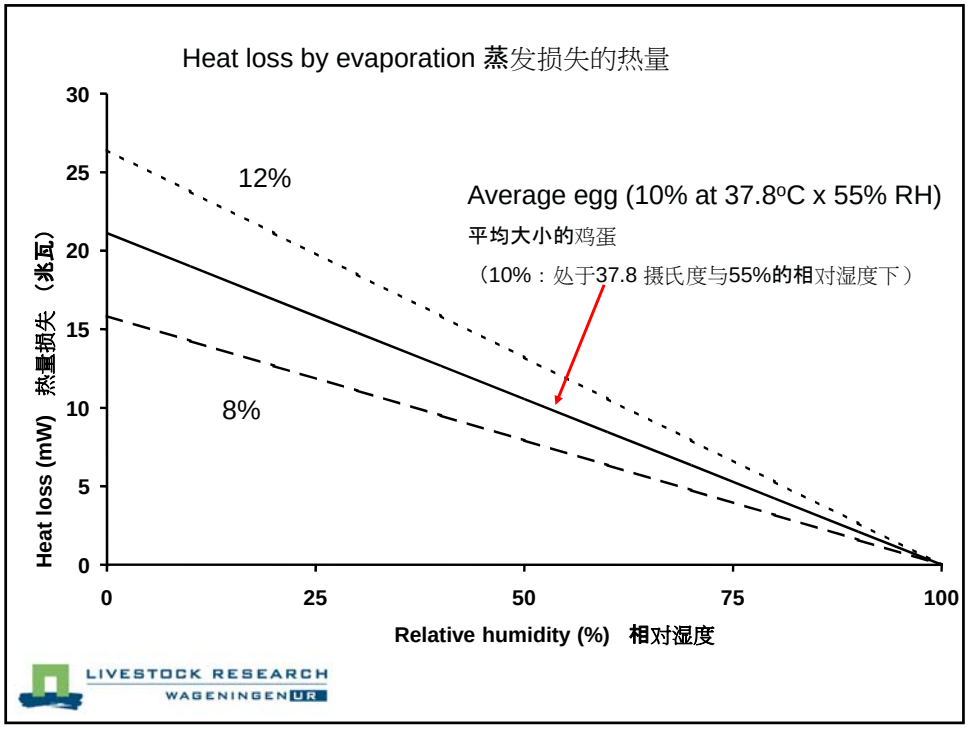
Heat loss by evaporation 蒸发损失的热量
30
25
20
15
10
5
0
12%
8%
Average egg (10% at 37.8ºC x 55% RH)
平均大小的鸡蛋
（10%：处于37.8 摄氏度与55%的相对湿度下）
Heat loss (mW) 热量损失（兆瓦）
0
25
50
75
100
Relative humidity (%) 相对湿度
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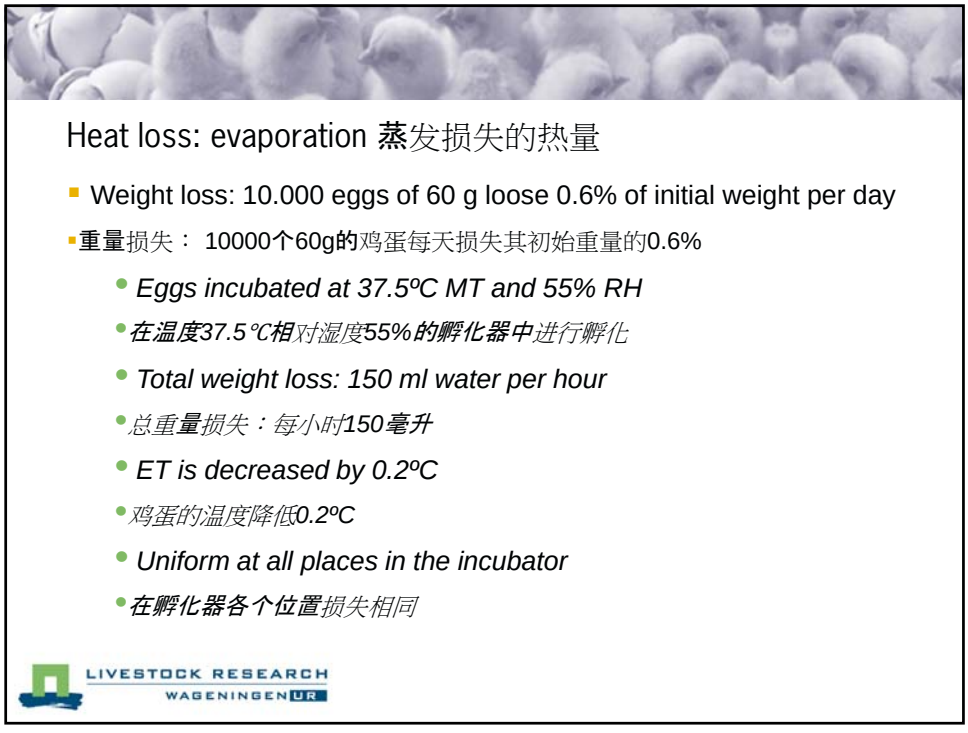
Heat loss: evaporation 蒸发损失的热量
Weight loss: 10.000 eggs of 60 g loose 0.6% of initial weight per day
重量损失： 10000个60g的鸡蛋每天损失其初始重量的0.6%
Eggs incubated at 37.5ºC MT and 55% RH
在温度37.5℃相对湿度55%的孵化器中进行孵化
Total weight loss: 150 ml water per hour
总重量损失：每小时150毫升
ET is decreased by 0.2ºC
鸡蛋的温度降低0.2ºC
Uniform at all places in the incubator
在孵化器各个位置损失相同
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Heat loss: evaporation 蒸发损失的热量

- Weight loss: 10.000 eggs of 60 g loose 0.6% of initial weight per day
- 重量损失： 10000个60g的鸡蛋每天的损失其初始重量的0.6%
  - *Eggs incubated at 37.5ºC and 55% RH 在温度37.5℃相对湿度55%的孵化器中进行孵化*
  - *Total weight loss: 150 ml water per hour 总重量损失：每小时150毫升*
  - *ET is decreased by 0.2ºC 胚胎温度降低0.2ºC*
  - *Uniform at all places in the incubator 在孵化器各个位置损失相同*
- Spray nozzles or humidifying discs: 喷雾降温或湿度阀盘
  - *Local cooling effects 局部冷却效果*
  - *150 ml water per hour at 10% of the eggs: ET is decreased by 2.0ºC!*
  - *10%的鸡蛋每小时损失150毫升水分：使得胚胎温度下降2.0℃*

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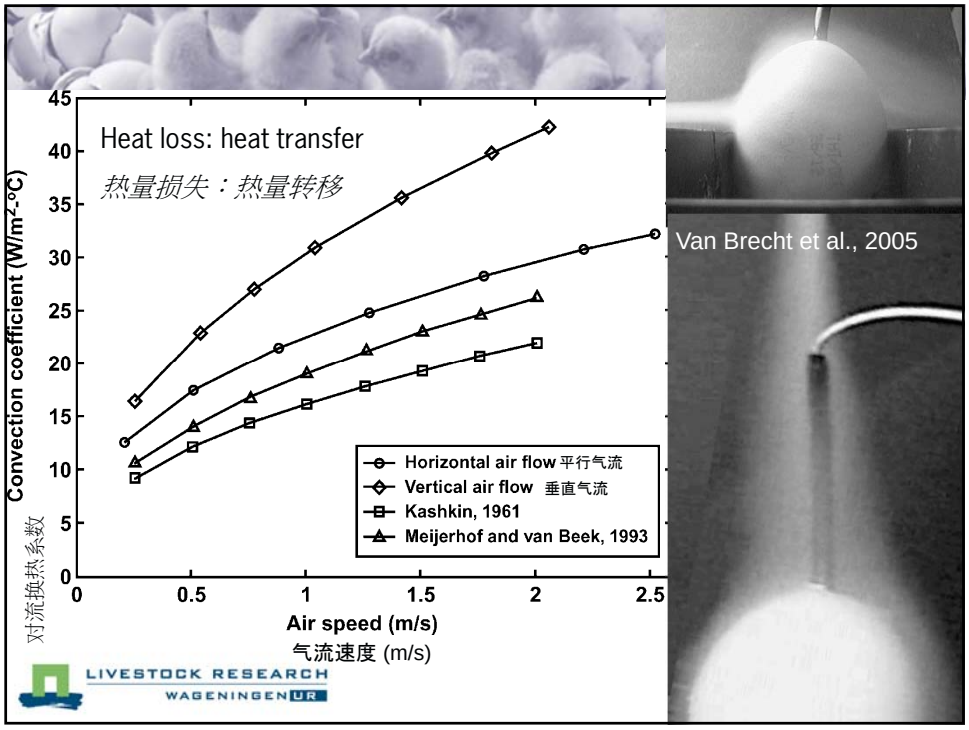
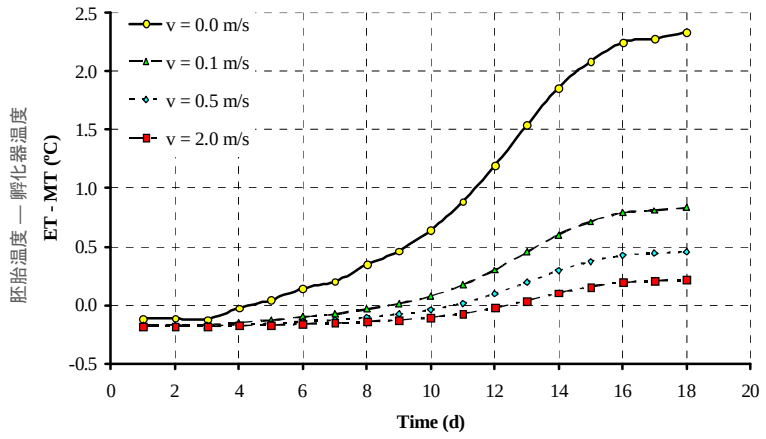


Heat loss: heat transfer 热量损失：热量转移



Calculated for eggs incubated at the same MT

相同的孵化器温度条件下的鸡蛋

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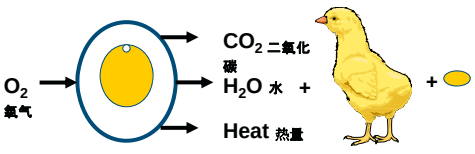
2. Factors that affect heat production 影响热量产生的因素

- Age of the embryo (time) 胚胎的发育阶段
- Physical factors 物理因素
  - *storage conditions, egg turning 储存条件，翻蛋控制*
- Biological factors 生物因素
  - *egg size, breed, breed age 鸡蛋大小，品种，日龄*
- Environmental factors 环境因素
  - *oxygen, carbon dioxide, humidity, temperature*

  氧气、二氧化碳、湿度、温度



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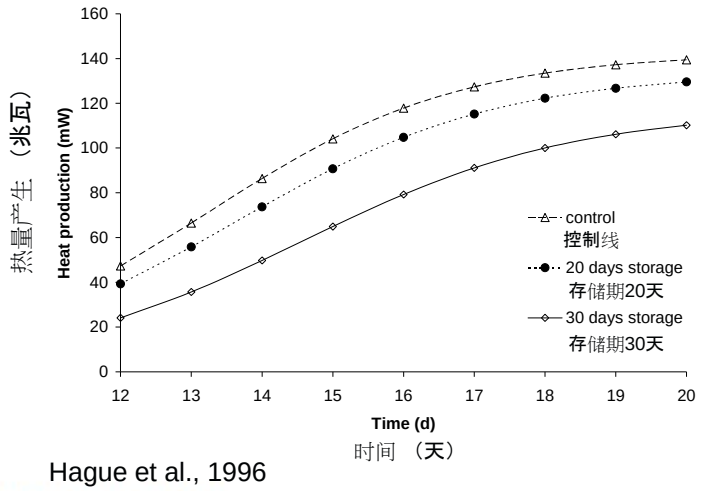
Physical factors: egg storage 物理因素：鸡蛋的存储



Hague et al., 1996

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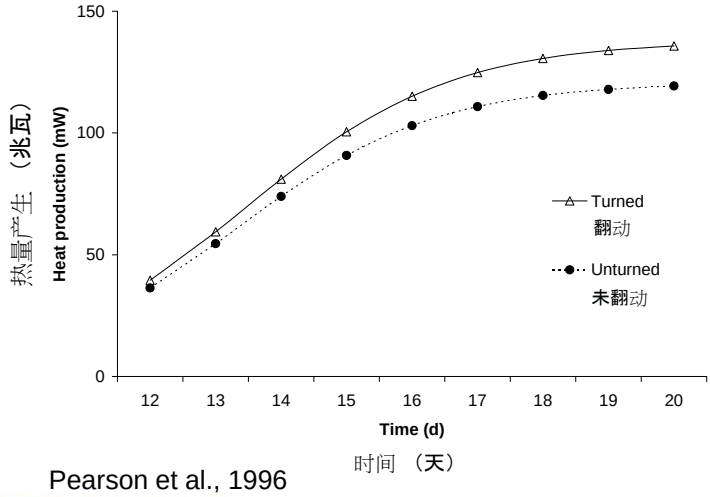
Physical factors: egg turning 物理因素：翻蛋控制



Pearson et al., 1996

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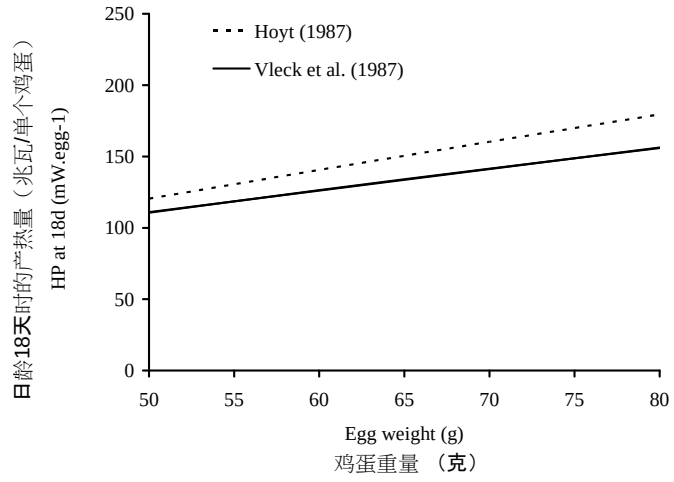
Biological factors: egg size 生物因素：鸡蛋大小



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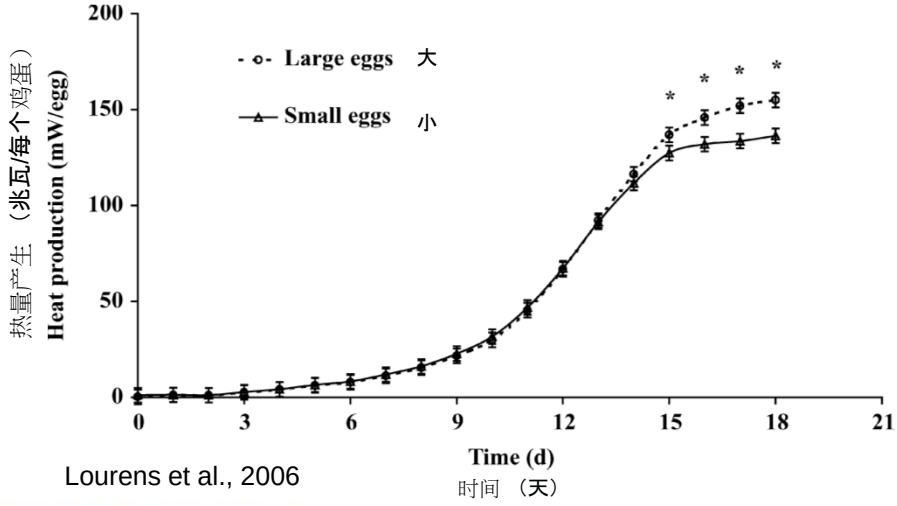
Biological factors: egg size 生物因素：鸡蛋大小



Lourens et al., 2006

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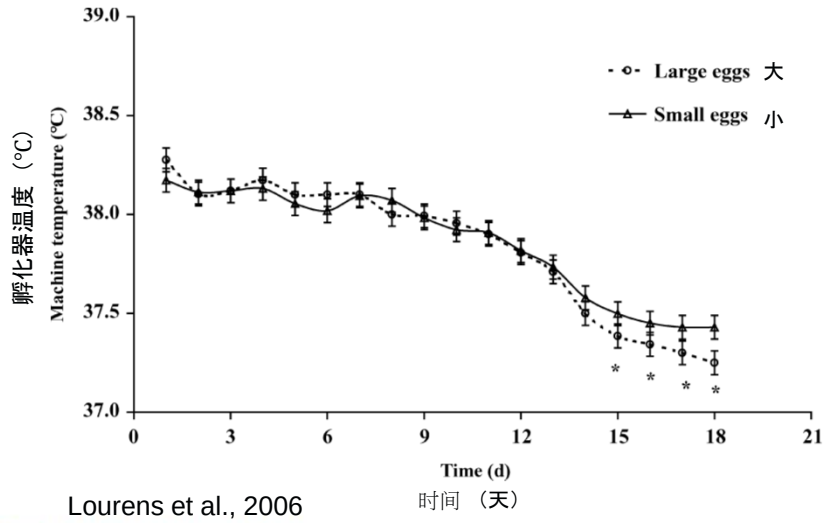
Biological factors: egg size 生物因素：鸡蛋大小



Lourens et al., 2006

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Biological factors: breed 生物因素：品种

Metabolic heat production (mW per egg)

代谢产热量（兆瓦/每个鸡蛋）

d 日龄	R308*	R508*	Layer* 蛋鸡	Traditional** 传统鸡
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)

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Differences between lines, genetic background
不同生产线和基因条件所造成的差异

- Not much “hard” information 并不是很『坚实（有科学依据）』的信息
  - Mainly focus on layers vs broilers 主要侧重于蛋鸡与肉鸡的区别

- But practical experience 但是基于实际经验：
  - Vedette, AA
  - Ross 308, hubbard classic, Hybro PN
  - Ross 508,
  - Ross 708, cobb 500, Hybro G+, Hubbard HY
  - Cobb 700, male lines

Easy 容易

Difficult 难

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- General trend 大致的趋势:
  - More meat yield ⇨ higher heat production
  - 更高的肉产量 ⇨ 更高的产热量
  - Better shell quality ⇨ more sensitive for heat
  - 更好的蛋壳质量 ⇨ 对热量更敏感

If people change breed, look where they come from

如果品种发生变化，应该注意其背后的原因是什么

- Ross to Cobb: possible problems 可能出现的问题
- R508 to R308: more easy 更容易
- Cobb 500 to Cobb 700: be aware 需要注意

- 0.5 to 1ºF higher embryo temperature at same setting 同样设置下，胚胎温度可以高出0.5 – 1 ºF
- 6-12 hours earlier hatch 提前6-12小时出壳
- More chick quality issues if temperature not adjusted 如果不调整温度，雏鸡会出现更多的质量问题

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Biological factors: breed 生物因素：品种

- Broiler and layer hatching eggs incubated at the same constant MT
- 在孵化器温度持续一致的情况下分别孵化肉鸡与蛋鸡
- Differences in egg size 鸡蛋的大小不同
- Eggshell temperature at d18 for layer eggs: 38.3ºC

  日龄为18天时，蛋鸡蛋壳的温度为38.3ºC
- Eggshell temperature for broiler eggs: 0,6 – 0,8ºC higher

  相比较而言，肉鸡蛋壳温度高出0.6 – 0.8ºC
  - metabolic rate higher 更高的代谢率
  - HP and ET are linearly related 热量产生与胚胎温度呈线性相关
  - oxygen conductance in broiler eggs higher? (poor eggshell quality?) 肉鸡蛋壳氧气传导性更高？（或者说，蛋壳质量更差？）
  - Broiler embryos contain and utilize more energy? 肉鸡胚胎所包含于产生的能量更多？
  - Efficiency of energy utilization?? 能量使用效率

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- Experiment with broiler hatching eggs (Lourens et al., 2007):
- 使用肉鸡鸡蛋进行孵化实验（ Lourens et al., 2007 ）
  - Eggs of similar size 鸡蛋大小类似: 60 – 65g
  - EST between d8 – d19 日龄8-19期间的蛋壳温度: 37.8ºC or 38.9ºC
  - O2 氧气量: 17%, 21% or 25%

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Climate Respiration Chamber (CRC)
气候调节型呼吸实验室（代谢室）

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Control Room 中控室

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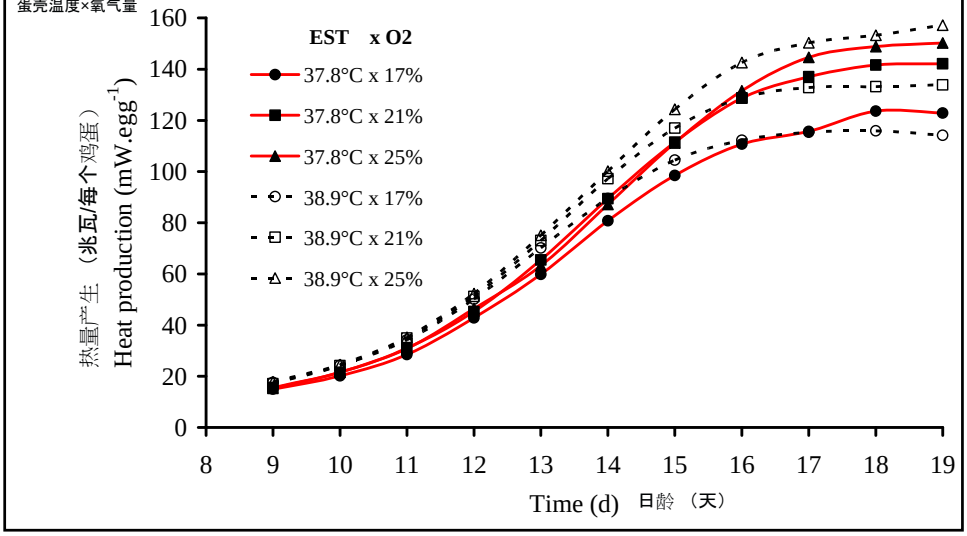
Source of variation 变量	9	10	11	12	13	14	15	16	17	18	19
EST 蛋壳温度	*	*	*	**	**	**	*	-	-	-	-
O2 氧气量	-	-	-	-	-	*	**	**	**	**	**
EST x O2 蛋壳温度×氧气量	-	-	-	-	-	-	-	-	-	*	*



	CL (cm)	BW (g)	YFB (g)	RY (g)	HW (g)	LW (g)	HT (d)
EST 蛋壳温度							
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]

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	CL (cm)	BW (g)	YFB (g)	RY (g)	HW (g)	LW (g)	HT (d)
EST 蛋壳温度							
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 氧气量							
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

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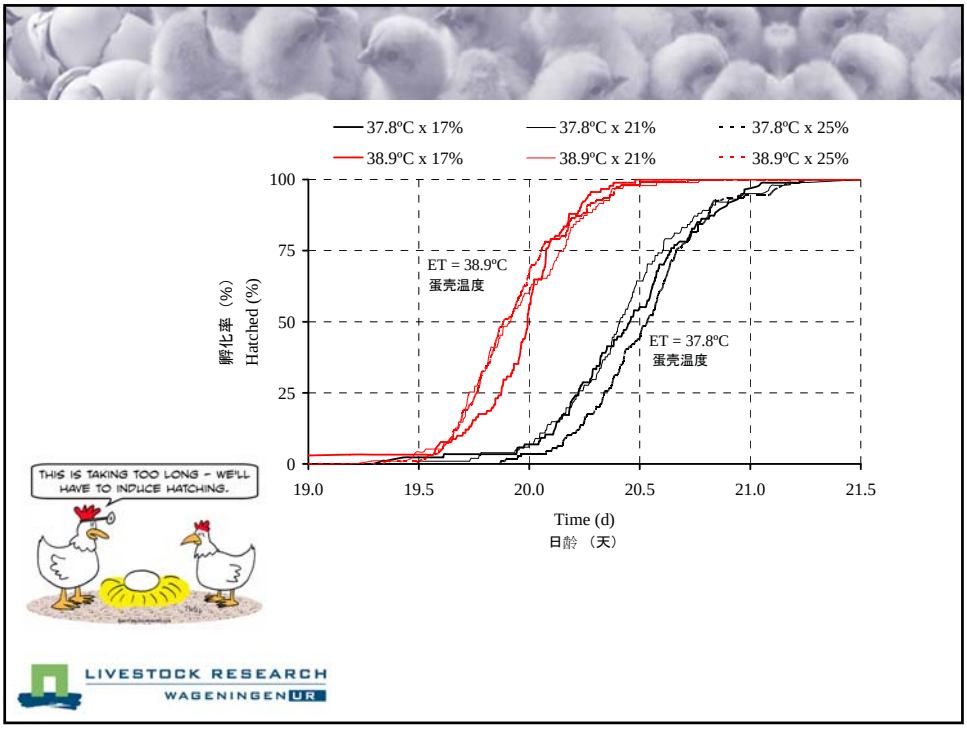

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In general, 简而言之

- For eggs of the same size, hatch time decreased when flock age increased

  大小相同的鸡蛋，随着鸡群日龄提高，孵化时间缩短

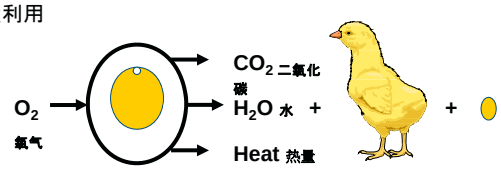
- Increased oxygen conductance in eggs of older flocks increased HP

  日龄较大的鸡蛋的氧气传导性提高，热量产生增加

- As a result, ET increased as well, which decreased hatch time!!

  结果：蛋壳温度提高，孵化时间缩短

- What factor determines HP? 哪些因素决定热量产生？
  - Energy utilization 能量利用
  - Efficiency 效率



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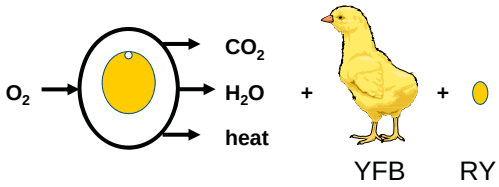
$$E_{YFB} = \frac{YFB\,(kJ)}{Albumen\,(kJ) + Yolk\,(kJ) - RY\,(kJ)} \text{ x}100\%$$

蛋白(千焦) 蛋黄(千焦)



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	EST蛋壳温度		O_2 氧气量		
	37.8°C	38.9°C	17%	21%	25%
Albumen (kJ) 蛋白	73	76	73	75	76
Yolk (kJ) 蛋黄	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) 能量使用	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 ($mW.egg^{-1}$) 日龄18天时的能量产生情况	131[b]	148[a]	119[c]	138[b]	152[a]

After Lourens et al. (2011).

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	Energy utilization 能量使用	E_{YFB}
Egg weight 鸡蛋重量	Yes是	No否
Breed 品种	Yes是	No否
Oxygen 氧气量	Yes是	No否
Eggshell temperature 蛋壳温度	No否	Yes是

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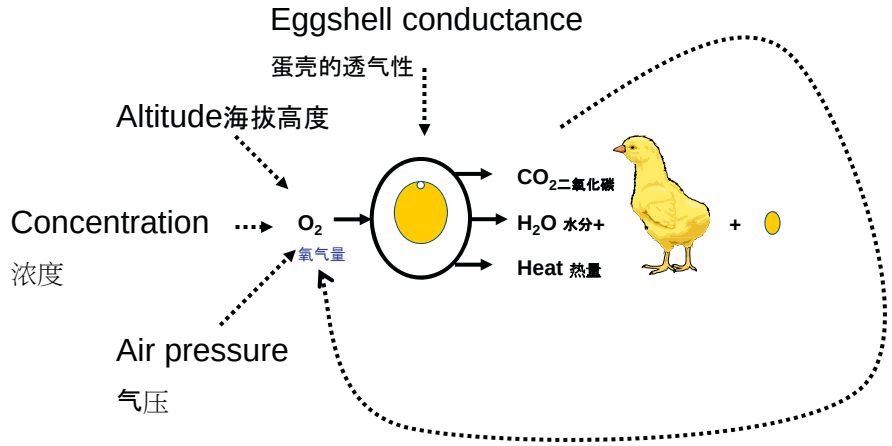
Environmental factors 环境因素



Oxygen availability to the embryo (red blood cells)
给胚胎供氧的能力 （血红细胞）

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Environmental factors: H_2O 环境因素：水分

- RH, MT, and conductance determine weight loss during incubation
  相对湿度、孵化器温度和蛋壳的透气性决定了孵化期间的重量损失
- Development of air cell, required for internal pipping 气室的变化和发展是破壳的基础条件
- But focus on ET first… 但是首先我们主要看看胚胎温度
- Ventilation early in incubation removes water from the machine
  在孵化早期进行通风会降低孵化箱中的湿度
  - Not required 不是必须的
  - Creates cold spots 造成冷点区域
  - Spray nozzles / humidifiers to add moisture 喷雾或加湿器：提高湿度
  - High CO_2 level during week 1 stimulates development of membranes to support gas exchange later in week 3 孵化第一周保持较高的二氧化碳水平可以促进内层卵壳膜的发展，进而为第三周时的换气打好基础
  - High RH during week 1 needs to be compensated later 孵化第一周较高的相对湿度需要在后期进行必要调整

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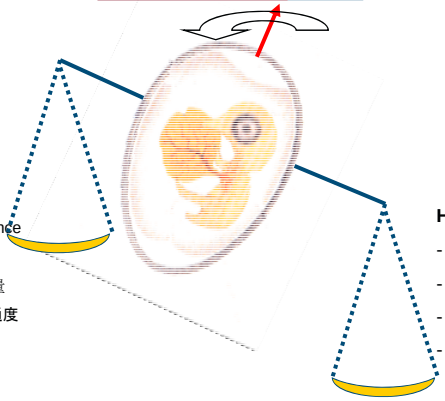
Embryo temperature (ºC) 胚胎温度

36.0 36.5 37.0 37.5 38.0 38.5 39.0 39.5 40.0



Heat loss 热量损失
- Evaporation 蒸发
- Heat transfer 热量转移
  - temperature difference
  -温差
  - heat capacity 热容量
  - air velocity 空气流通度

Heat production 热量产生
- Time / development 日龄/发育期
- Physical factors 物理因素
- Biological factors 生物因素
- Environmental factors 环境因素

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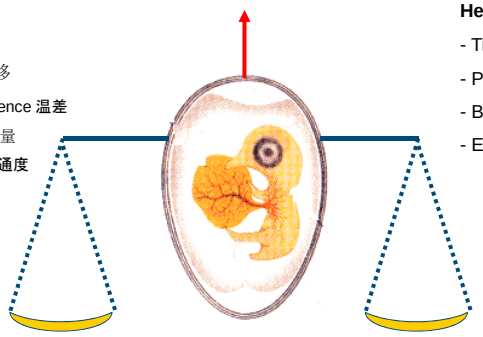
ET: balance between heat production and heat loss
胚胎温度：在热量产生与损耗之间寻找平衡

Embryo temperature (ºC) 胚胎温度

36.0 36.5 37.0 37.5 38.0 38.5 39.0 39.5 40.0

Heat loss 热量损失

- Evaporation 蒸发
- Heat transfer 热量转移
  - temperature difference 温差
  - heat capacity 热容量
  - air velocity 空气流通度



Heat production 热量产生

- Time / development 日龄/发育期
- Physical factors 物理因素
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- Environmental factors 环境因素

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ET: balance between heat production and heat loss

Treatment 处理	1-7 days 第 1-7 天	7-14 days 第 7-14 天	14-21 days 第 14-21 天
	98	**100**	**100**
“multi-stage” 多阶段	**98**	**100**	**102**
“single-stage” 单阶段	**100**	**100**	**100**
	100	**100**	**102**

temperature values are egg shell temperatures 蛋壳温度至关重要

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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

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Take home message 小结:

Eggshell temperature is the key!!!
蛋壳温度是最关键的
To know EST, you have to measure it
掌握蛋壳温度需要自己去测量
Keep EST close to 37.8ºC constantly
使蛋壳温度维持在37.8℃的水平

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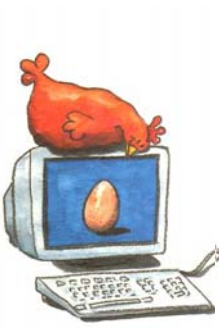
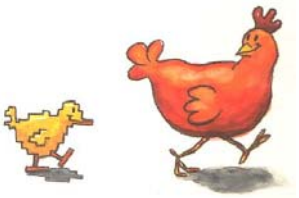


Thanks for your attention!!

谢谢**大家！**



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