Hot Weather Ventilation Principles
夏季通风原则

Keeping birds cool during hot weather is all about air speed…
夏季确保鸡凉爽的关键在于控制空气流通速度
not the evaporative cooling pads
而不是靠蒸发式水帘降温

Let's take a look at a very good example of this fact
让我们来看一个例子

Broiler farm growing +3.6 kg bird (11 birds per $m^2$ , July – August flock )
商品鸡场，鸡均重+3.6kg，饲养密度为 11 只/平米，饲养时间：7-8 月

Outside temperature during the last three weeks of a 59 day-old flock
59 日龄鸡群饲养最后三周的室外温度

Outside temperature/Rh during the last three weeks of a 59 day-old flock
59 日龄鸡群饲养最后三周的室外相对湿度

Inside temperatures during the last three weeks of a 59 day-old flock
59 日龄鸡群饲养最后三周的室内温度

Inside and outside temperatures during the last three weeks of a 59 day-old flock
59 日龄鸡群饲养最后三周的室内外温度

Evaporative cooling system usage…
蒸发式水帘的作用
Only a total of 9 hours, over the course of three days
三天内开启 9 小时

Inside and outside temperatures during the last three weeks of a 59 day-old flock
59 日龄鸡群饲养最后三周的室内外温度

Litter was dry…
垫料偏干
Even in front of the pads
即使是湿帘前边的垫料也太干

Birds were clean…
鸡很干净

Paws/feet looked very good
鸡爪的状况看上去很好

Performance?
性能指标情况

Best performance of any the 15 farms he was competing against for that week.
对比的 15 个农场的最好指标为：
3% total mortality 死亡率：3%
Second highest weight = 3.8 kg 第二高重量：3.8kg
5 grams below heaviest (which 3 days older) 比最重的轻 5g （最重的多养了 3 天）
Best feed conversion by 8.5 points 最好的饲料转化率：8.5
Condemnations were ½ that of any other farm 死淘率是其他农场的一半

The key is the house had an average air speed of 3.5 m/sec (700 ft/min) 如此好的指标主要归功于这个鸡舍的平均空气流通速度为 3.5m/秒，

and most importantly it was very uniform from wall to wall
最重要的是两面墙之间的风速能保持一致。

To understand why they used their evaporative cooling pads so little we need to review how a bird deals with heat
要理解为什么蒸发式湿帘使用的时间这么短，我们需要先看一下鸡对高温的反应。

Heat stress is essentially an internal problem caused by the consumption of feed
高热反应从根本上来说是一种体内由于饲料的消耗引起的问题

Feed is a basically a fuel…
饲料基本上也可以看做是一种燃料
Birds consume/burn feed which has an energy density similar to that of chocolate cake with frosting.
鸡消耗的饲料具有跟巧克力蛋糕类似的能量密度。

How much fuel does a bird consume on a daily basis?
鸡每天需要消耗多少饲料？

A 2.7 kg broiler is supposed to eat roughly 160 grams of feed a day
一只 2.7kg 的鸡每天需要进食 160g 饲料

In terms of calories…
换算成热量

| Broilers | Humans |
|---|---|
| Consume 264 calories per kg of body weight. | Supposed to consume 55 calories per kg of body weight. |

肉鸡
每公斤体重需要消耗 264 卡路里的能量
人类
每公斤体重需要消耗 55 卡路里的能量

To put this in perspective…
换一种说法

I would need to eat roughly 20 Big Mac meals each day.
我每天需要吃掉 20 份麦当劳套餐
Or 200 cans of Coke
或者 200 罐可乐
Or 227 medium sized apples
或者 227 个中等大小的苹果

Or if I ate chicken feed…
如果转换成鸡饲料的量
I would need to eat roughly 6.4 kgs of chicken feed each day.
我需要每天吃掉 6.4kg 鸡饲料

How does a broiler use this feed energy?
肉鸡是如何使用这些饲料能量的？
Roughly 35 – 40 % of the energy is used to power the basic functions of life:
35%-40%用来维持基本的生命体征
Grow, move around, breath, pumping blood, maintain body temperature, etc.
生长，活动，呼吸，血液循环，维持体温等

The remaining 60 - 65% is essentially put off in the form of heat.
剩余 60%-65%基本以热量形式释放出去
Heat a bird must rid itself of in order to maintain a proper body temperature and survive.
鸡必须释放热量以保持合适的体温，维持生存

In a way, a chicken is not really that different from an automobile engine
某种程度上，鸡与汽车发动机有些类似
The typical automobile engine is only about 25% efficient.
典型的汽车发动机效率只有 25%
The remainder of the energy goes out the radiator and tail pipe
其余的能量通过散热器和尾管排放出去

And like an automobile engine…
跟汽车发动机一样

What produces more heat…per kg
什么能产生更多的热量

As you might suspect bird body temperature tends to follow feed consumption
你也许会猜测鸡体的温度会与消耗的饲料量有关

Water/Feed consumption patterns for birds on a restricted lighting program
在严格的光照控制下鸡的水/饲料消耗模式

Bird temperature logger
体温记录仪

Room temperature patterns

室温变化情况

Room and body temperature patterns
室温与体温变化情况

If you restrict feed…restrict heat production
控制进食量，控制热量的产生

Body temperature patterns: unrestricted feed
不控制进食量的情况下体温变化趋势

Body temperature patterns: restricted feed
控制进食量的情况下体温变化趋势

But of course if you restrict feed, you restrict growth
如果控制进食量会抑制生长速度

How much heat are we talking about?
我们谈论的热量有多少？

At 21 C a 2.2 kg broiler (consuming approximately 90 grams of feed per day) produces approximately 60 Btu's of heat each hour…
在 21 摄氏度时，体重为 2.2kg 的肉鸡（每天消耗约 90g 饲料）每小时产生约 60BTU 的热量

Same heat as produced by a 25 watt incandescent light bulb
等同于一只 25 瓦的白炽灯泡产生的热量

Same heat as produced by 60 matches
等同于 60 根火柴燃烧产生的热量

12 m X 150 m Broiler house (23,000 – 3.5 kg birds)
12 米*150 米鸡舍（饲养 23,000 只 3.5kg 鸡）产生的热量情况
120 liters of gasoline per hour 每小时 120 升汽油

Thermal images are very telling of the amount of heat broilers are generating
热成像很好的显示出肉鸡产生的热量情况

How does this compare to us?
这些热量与我们人类产生的热量相比较是什么情形？

Seated at rest the average adult male will produce approximately 340 Btu's of heat each hour…
成年男子坐着休息时每小时能产生 340BTU 热量

1/7 of the heat per kg produced by a broiler
是肉鸡每公斤体重产生热量的 1/7

Whether it is winter or summer they must get rid of this heat to survive
无论是在夏季还是冬季鸡都需要释放这边热量来维持生存

How does a bird rid itself of this excess heat?
鸡怎样才能释放这些多余的热量？

A bird rids itself of this excess heat primarily in two ways:
两种途径：

1) To the air around it
释放至周围的空气中

2) Through the evaporation of moisture off of its respiratory system
通过呼吸系统蒸发的水分

Five pound bird at 21 C – 50% Rh producing 60 Btu's/hr
五磅的鸡在 21 度，50%的相对湿度下，每小时产生 60BTU 热量

25 Btu's/hr is lost to the air surrounding the bird (40%)
25BTU（40%）会释放至周围的空气中

35 Btu's/hr is lost through the evaporation of water off of its respiratory system (60%)
35BTU（60%）通过呼吸系统蒸发的水分释放

How do we compare?
与人类对比是什么情形？

Seated at rest the average adult male will produce approximately 340 Btu's/hr
成年男子坐着休息时每小时能产生 340BTU 热量

28% is lost due to the evaporation of water from our respiratory system and skin (perspiration)
28%通过呼吸系统蒸发的水分和皮肤汗液释放

72% is lost to the air surrounding us
72%会释放至周围的空气中

This is a very significant difference
人类和家禽在释放热量的方式上差异很大

Generate a lot more heat and are MUCH more sensitive to humidity than we are
家禽产生的热量比人类多，并且对湿度更加敏感

Lets take a closer look at how temperature and humidity affect heat loss from a bird…
让我们来看一下温度和湿度如何影响鸡热量的流失

Heat loss from a 2.2 kg broiler at 21 C, 50%
2.2kg 鸡在 21 度，相对湿度为 50%的热量流失情况

What happens when we increase air temperature to 25oC
如果把温度提高至 25 度会发生什么情况

Heat loss from a 2.2 kg broiler at 21 C and 25oC, Rh=50%
2.2kg 鸡在 25 度，相对湿度为 50%的热量流失情况

House conditions / Heat removal 鸡舍环境/热量流失
But heat loss to the air is not a birds only way birds lose heat…
释放至空气中并不是鸡热量流失的唯一途径

Heat loss from a 2.2 kg broiler at 21 C and 25oC, Rh=50%
2.2kg 鸡在 21 度/25 度，相对湿度为 50%的热量流失情况

House conditions / Heat removal 鸡舍环境/热量流失

Bird body temperature vs Air temperature 鸡体温与室温变化情况

What happens at even higher house temperatures? 室温更高的情况下会发生什么？

Heat loss from a 2.2 Kg broiler 2.2kg 肉鸡热量流失情况

House conditions / Heat removal 鸡舍环境/热量流失

Heat loss from a 2.2 Kg broiler 2.2kg 肉鸡热量流失情况

If a bird cannot get rid of all the heat it is producing… 如果一只鸡无法将产生的热量释放出去

Body temperature will increase, 体温会升高

Bird and house temperature 鸡体温与室温变化情况

If a bird cannot get rid of all the heat it is producing… 如果一只鸡无法将产生的热量释放出去
Body temperature will increase, 体温会升高
Feed consumption will decrease, 饲料消耗量会下降
Growth rate will decrease, 生产速度会减慢
Feed conversions will increase, 饲料转化率会增大
Eventually mortality will increase. 死亡率会增加

How does changing the humidity affect the heat loss from a bird?
湿度的改变会对鸡的热量流失产生什么影响？
Study at looking at how relative humidity affects heat loss from a 2.2 kg bird at 25oC
研究下 2.2kg 肉鸡在 25 度室温下，热量流失如何受相对湿度的影响
Rh 50%, 70% and 90%
相对湿度取 50%，70%，90%

Heat loss from a 2.2 kg broiler at 25 C 2.2kg 鸡在 25 度时的热量流失

If a bird cannot get rid of all the heat it is producing… 如果一只鸡无法将产生的热量释放出去
Body temperature will increase, 体温会升高
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Increasing Rh from 50 to 70 % when it is 25oC
在室温为 25 度时，将相对湿度由 50%增加至 70%
Feels the same to the bird as raising the air temperature from 25 to 30oC when the Rh is 50%
相对湿度为 50%时，室温由 25 度提高到 30 度对鸡无影响

Humidity is equally important to young birds 湿度对小鸡同样重要

Effective temperature for day-old chicks 1 日龄雏鸡的实感温度

Target temperature/Rh 目标温度/湿度

| Age | Temperature | Rh |
|---|---|---|
| Day old | 30oC | 50 – 70% Rh |
| 1 日龄 | 30 度 | 相对湿度 50-70% |

Target temperature as a function of Rh
不同湿度下的目标温度

| Age 日龄 | Temperature 温度 | Dry Bulb Temperature at Rh% 不同湿度下的干球温度 |
|---|---|---|

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Rh 50%, 70% and 90%
相对湿度取 50%，70%，90%

Heat loss from a 2.2 kg broiler at 25 C 2.2kg 鸡在 25 度时的热量流失

What happens at high house temperatures (30oC) with very high relative humidity?
在 30 度高温高湿的条件下会发生什么情况？

Heat loss from a 2.2 kg broiler 2.2kg 鸡的热量流失

So how do we help remove heat from the birds?
我们怎么才能帮鸡散热？
Lower the air temperature?
降低室温？

Evaporative cooling
蒸发式湿帘
Pads/fogging nozzles produce cooling through the evaporation of water into the air which increases relative humidity of the air
湿帘/喷雾嘴通过水分的蒸发降温，同时增加相对湿度

6” (15 cm) evaporative cooling pad in operation

15cm 的蒸发式湿帘效果
For every 1 C cooling produced by the evaporation of water the relative humidity will increase approximately 4.5%
通过水分蒸发降温 1 度，湿度会增加 4.5%

So we are left with a choice…
所以我们可以选择：

Evaporative cooling 蒸发式湿帘
Evaporative cooling without air movement does not decrease heat stress in poultry.
只有湿帘无空气流通，降温效果并不好
The key to bird heat removal is air movement.
降温的关键在于加强空气流通

Increase the air movement over the birds…
增加空气流动
Increase the transfer of heat from the bird to the air
增加热量从鸡体到空气的转移

Broilers 肉鸡
1.75 m/sec 空气流通速度：1.75 米/秒

Broilers 肉鸡
2.5 m/sec 2.5 米/秒

Broilers 肉鸡
30oC - 2 m/sec 30 度 2 米/秒

Broilers 肉鸡
30oC - 3 m/sec 30 度 3 米/秒

Five pound bird 30 C 五磅的鸡，室温 30 度

Heat removal due to air speed 12 m X 150 m house – 2 kg birds (3 day period)
热量流失与空气流动的关系（12 米*150 米鸡舍，2kg 鸡，3 天内的变化）

Heat removal due to air speed 12 m X 150 m house – 2 kg birds (3 day period)
热量流失与空气流动的关系（12 米*150 米鸡舍，2kg 鸡，3 天内的变化）

Heat removal due to air speed vs Air speed 12 m X 150 m house – 2 kg birds
热量流失与空气流动速度的关系（12 米*150 米鸡舍，2kg 鸡）

Five different 15 m X 150 m houses (3 Kg+ birds) 5 个不同鸡舍的对比（3kg 以上鸡）

Body temperature vs Air speed 鸡体温与空气流通速度的关系

Bird temperature – no air movement 无空气流通情况下鸡体温变化趋势
Bird temperature – with air movement 有空气流通情况下鸡体温变化趋势

Bird temperature Without air movement 无空气流通情况下鸡体温变化趋势

House conditions With 4.5 lb birds 鸡舍温度变化情况（4.5 磅鸡）

4.5 lb bird temperature With air movement 4.5 磅鸡在有空气流通情况下的体温变化趋势

Respiration rate vs. Air speed 呼吸频率与空气流通速度的关系（室温 30 度）

Reduces the effect of high humidity 减少高湿度的影响

The higher the air speed the less important Rh becomes 空气流通越快，湿度的影响越小

Air speed also aides the removal of trapped heat from between the birds
空气流通快有利于鸡只之间的热量排放

Hot air between birds 鸡只之间的热量

Wind speed and bird heat removal 风速与热量流失的关系

All these factors result in the birds feeling much cooler than the thermometer indicates
所有的这些都会使鸡感觉比温度计上的实际温度要凉爽的多

Cooling effect vs wind speed 风速对降温的影响

Increased cooling effects result in improved bird performance 降温效果好，会改善生长性能

Broiler weekly weights 肉鸡周重量变化趋势

Weekly feed conversions 肉鸡周饲料转化率

But, air movement is only effective if the birds are spread out
只有在鸡均匀的分散开时，空气流通才会起作用

Good example of the effect of density on cooling 饲养密度对降温的影响

29 C – 450 ft/min air speed 29 度，风速 450 英尺/分钟

Very little of the birds surface is actually being cooled 少数的鸡体表温度会降低

Birds at tunnel fan end are actually cooler… 在风道末端的鸡会更凉爽些

Another farm… 另一个农场

Walking through birds near tunnel opening… 通风口附近的鸡
Tunnel fan end of the house. 鸡舍末端风道口

How much air speed should a house have?
鸡舍需要的空气流通速度是什么？
The proper air speed depends on a variety of factors:
合适的空气流通速度与以下因素有关
- Bird size 鸡只大小
- Density 饲养密度
- Climate (temperature/rh) 温度/湿度
- Bird age 日龄
- Etc. 其他

But there are some general guidelines
除此之外，有一些基本的原则

General tunnel velocity guidelines
风速基本原则

Broilers 肉鸡
400 - 800 ft/min
2.0 – 4 m/sec

Breeders 种鸡
400 - 600 ft/min
2.0 – 2.75 m/sec

Breeder pullets 育雏
350 - 450 ft/min
1.75 – 2.25 m/sec

Do we really need evaporative cooling? 是不是真的需要蒸发式水帘？

As air temperature increases heat removal through air movement decreases
通过空气流通的减少,空气温度的变化会加快热量的散失

Bird heat loss @ 600 ft/min (3 m/sec)
鸡热量的流失（空气流通速度为 3 米/秒）

Evaporative cooling purpose is to keep the air temperature 30oC or lower
蒸发式水帘的作用是确保空气温度保持在 30 度以下
So our air movement remains effective in removing heat from our birds
在此条件下，空气流通才能有效的使鸡只散热

Evaporative cooling should NEVER be used below 29oC
空气温度低于 29 度时不要使用蒸发式水帘
- It is not needed if you have sufficient wind speed. 空气流通速度足够时，不需要开启
- Will inevitably lead to wet litter 会导致垫料潮湿

Will actually lead to increased heat stress 会加大高温对鸡只造成的影响

Nighttime temperature and relative humidity 夜间温度&相对湿度

As temperature decreases relative humidity increases 温度降低，相对湿度增加

At temperatures below 29 C…Relative humidity is typically above 80% 温度低于 29 度时，相对湿度通常会高于 80%

Pads produce little cooling and push the relative humidity near 100% 蒸发式水帘会使温度降低，将相对湿度提高到 100%

Respiratory heat loss vs. Relative humidity 呼吸热损失 vs 相对湿度

Air speed vs. Bird age 空气流通速度 vs 鸡只日龄

For the last two weeks of a flock ALL tunnel fans should be operating before the evaporative cooling is used.

饲养周期的后两周，在蒸发式水帘使用之前，需要开启所有的风机

Air speed vs. Bird age 空气流通速度 vs 鸡只日龄

For the first two weeks of a flock air speed should be generally limited to <300 ft/min (1.5 m/sec)

饲养周期的前两周，确保空气流通速度低于 1.5 米/秒

For the weeks in between air speed should be increased weekly

饲养周期的中间几周，空气流通速度需要每周逐渐提高

Just because evaporative cooling lowers the temperature 尽管蒸发式水帘能降温

Doesn't mean you can run fewer fans.

并不意味着可以少开风机

Example of how pads shutting off fans can increase heat stress 举例说明在开启蒸发式水帘的情况下关闭风机会增加鸡的高温反应

Studying water consumption usage and patterns in breeder houses.

研究种鸡鸡舍水的消耗量

Normal water consumption pattern 正常情况下水的消耗

Hot bird consumption pattern 高温情况下水的消耗

Spiking of water consumption on hot days 高温天气下水消耗量高峰

Spiking of water consumption and house conditions 水消耗量高峰与鸡舍情况

Water consumption spikes occurred when temperatures were their lowest? 当温度低时会出现水消耗量的高峰