Managing heat stress – Part 1

Layers respond to hot climatic conditions

Layers in hot climates are exposed to high temperatures, which may lead to a loss of productivity. Proper measures can be taken to manage such conditions, but this demands an understanding of the bird's physiology.

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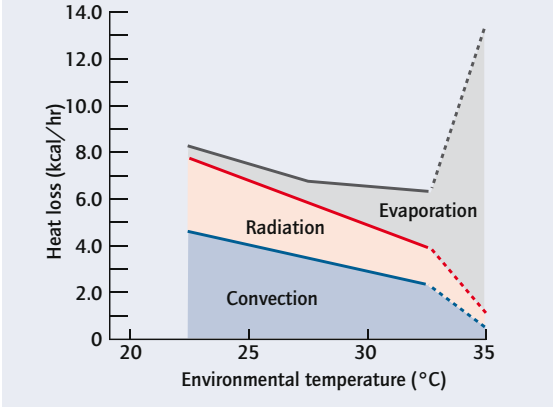
In many developing countries poultry production is based mainly on traditional extensive poultry production systems. It has been estimated, for example, that 80% of the poultry population is found in traditional family-based poultry production systems, contributing up to 90% of poultry products in low income countries like Ethiopia.

Heat stress often is a common problem in such countries. High ambient temperatures can be devastating to commercial broilers and layers. Coupled with high humidity, high temperatures can have even more harmful effects. Heat stress interferes with the birds comfort and suppresses productive efficiency.

During periods of heat stress the hens have to make major thermo-regulatory adaptations to prevent death from heat exhaustion. As a result, the full genetic potential of the layer is often not achieved. The purpose of this article is to review some of the effects of heat stress on layers, and to look at methods that can be used by the poultry producer to partially alleviate some of the detrimental effects of heat stress on the birds' productivity.

Figure 1 - Radiation, convection and evaporation with increasing house temperature



Removing excessive body heat

The body temperature of a hen varies between 40 and 42°C, depending on the time of day (before and after feeding, night time), feather cover (in connection with moulting), brooding, and environmental temperature. The ideal environmental temperature for chickens is 18-24°C. If temperatures exceed 24°C, the bird has a number of possibilities to release excessive body heat:

- **Radiation**

Heat loss is proportional to the temperature difference between the body surface and the surrounding air. Poorly insulated, hot roofs will increase house temperature and heat stress on sunny days, similar to direct sun on free range birds without shade.

- **Convection**

The hen's hot body will release hot air into the surrounding environment. This process can be assisted by providing moving air fast enough to break down the layer of still air surrounding the body.

- **Conduction**

Heat may flow surface to surface, such as when the birds stand or sit on cool litter or cool water pipes. Usually the litter has a similar temperature as the house and water pipes are insulated.

- **Evaporation**

Since the bird's skin has no sweat glands, evaporation takes place through panting. This is only effective if the humidity is not too high. Hot and humid conditions are therefore much more stressful than hot and dry conditions. In order to lose 1 ml of water, the chicken uses 540 kcal, and this energy loss may result in a significant drop in production.

Body and environmental temperature

As illustrated in *Figure 1*, the rate of losing body heat through radiation and convection decreases with increasing temperature, and the bird has to rely mainly on temperature regulation via evaporation.

As mentioned in *Figure 2*, 18 - 24°C is the ideal environmental temperature for a hen. Up to a temperature of about 30°C the hen can still regulate body temperature, but when the house temperature reaches 40°C the body temperature will increase dramatically.

If stocking density is high, the radiant heat between the birds accumulates and the temperature increases.

When exposed to a 30°C environment, the hen will eat less feed, thereby resulting in smaller egg size and eventually lower egg production.

When the temperature increases from 30 to 38°C, shell quality is likely to deteriorate as indicated by increasing percentage of cracked eggs. Above 38°C the bird can only get rid of body heat through severe panting, which produces respiratory alkalosis. This physiological response is characterised by an increase in blood pH (more basic) along with a decrease in blood CO_2 concentration. It upsets the acid-base balance and produces a decrease in blood calcium and bicarbonate, which are necessary for the production of strong egg shells. As a result, more thin-shelled eggs will be produced.

From 41°C the risk of death is high and emergency measures have to be taken. A temperature of 47°C is lethal.

Rising temperatures will cause the hen to eat less feed, but also to drink more water. Water:feed intake ratio at 15°C, for example, is 1.82:1. However, when the temperature reaches 30 - 35°C, the water:feed ratio will be 4.9:1, which is quite a common situation with open houses in hot climates. *Table 1* shows the effect of ambient temperature on production, egg weight and feed conversion.

Layers reared in high temperatures from a young age can adapt to some extent and may reach good productivity levels. These hens will typically develop larger wattles and combs. Additionally, these birds will have less fat and feather coverage. *Figure 3* shows how the body temperature adapts to high temperatures within 14 days.

Practical measures

Good management practices include attention to the following possibilities to minimise heat stress.

• Stocking density

Heat loss often depends on the difference between the body temperature of birds and the ambient temperature. If stocking density is high, the radiant heat between the birds accumulates and the temperature increases. Therefore, the birds cannot lose body temperature (*Table 2*).

• Bird handling

During the hotter periods of the day any additional stress on the birds should be avoided. Vaccination, beak trimming, transfer, or any other kind of handling should be done during the coolest period of the day, if necessary at night. In any case, handle the birds as calmly and gently as possible.

• Water temperature

Birds can reduce body temperature by drinking cool water. Researchers Leeson and Summers exposed layers to an environmental temperature of 33°C. Cool water of 2°C was given to half of the flock., while the other half received water of 33°C. The birds with access to cool water consumed 12 g more feed per day than the group given warm water, resulting in 12% higher production, with slightly reduced egg weight due to the higher rate of lay.

Cool water of good quality should therefore be supplied at all times. This requires that the water tanks are properly insulated. The tanks should be light in colour, shaded and filled up to 80% capacity to keep the water cool.

Table 1 - Effect of house temperature on egg production, average egg weight and feed consumption per egg, relative to the optimum of 16°C

Temperature (°C)	Production	Egg weight	Feed/egg
16	100	100	100
18	100	100	95
21	100	100	91
24	100	99	89
27	99	96	86
29	97	93	85
32	94	86	84

Table 2 - Recommended stocking density with increasing house temperature

Temperature (°C)	Litter (birds/m²)	Cages (cm²/bird)
25	5.5	450
30	4.5	550
35	3.5	650

Commercial layers are kept in traditional houses, such as here in Cameroon.

Changing the acid-base balance of the water through the addition of NH4CL or HCL or KCL is recommended.

The tanks should be light in colour, shaded and filled up to 80% capacity to keep the water cool.

Figure 2 - Relation between body temperature (Tb) and environmental temperature

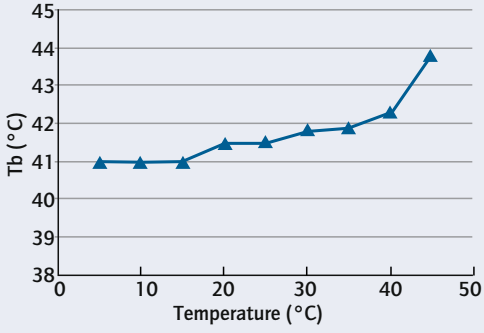
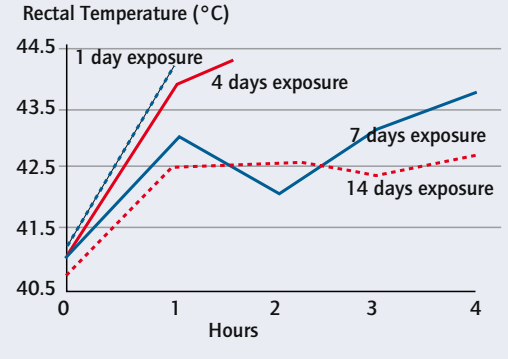


Figure 3 - Adaptation of hens to high temperatures



Pipes should be insulated and/or buried 1-2 m underground. The lines in the house should be cooled by flushing water lines with fresh cool water 2-3 times a day. The pipes in the house should not be installed close to the roof to avoid heat from the roof warming up the water in the pipes. If bell drinkers are used, water should be changed 2-3 times a day. It is essential that sufficient drinkers are available.

Changing the acid-base balance of the water through the addition of NH4CL or HCL or KCL is recommended. The addition of 5% KCL has shown a significant increase of water intake.

• **Feeding time**

Feeding at the right time of the day is very important to help the birds cope with heat stress. During late afternoon a significant rise in body temperature can be observed, which, in severe cases, can cause bird mortality. This is not the hottest time of the day, but it is the peak time of digestion if the birds have been fed in the early/mid morning. A good strategy to take an unnecessary heat load off the birds is to withdraw feed 8 hours prior to the anticipated time of peak temperature. One third of the daily feed ration should be given in the morning and two thirds in the late afternoon. An additional advantage is the availability of calcium in the digestive system during shell formation at night and in the early hours of the morning. This will improve shell quality and prevent the birds from depleting bone calcium.

So-called 'midnight snacks' are a good tool to give hens extra feeding time in the cooler parts of the night. This does not necessarily need to be done at midnight, but rather 3 hours of darkness before and after the extra 1-2 hours of light is essential to avoid disturbing the lighting programme.

• **Feed stimulation**

There are some simple strategies to stimulate feed intake.

- Run the feeder chains more frequently. Empty them to avoid overflow if need be.
- Feeders should run empty at least once a day to enhance the appetite and to ensure that the fine particles of the feed (premixes, vitamins etc.) are consumed.
- The feed texture should not be too fine. Oil can be used to avoid "dusty" feed.

• **Nutrition**

ME requirement decreases as ambient temperature increases to above 21°C, resulting from a reduction of energy requirements for maintenance. The energy requirement will decrease with the rise of temperature up to 27°C, above which it will start to increase again since the bird needs additional energy for panting to reduce body heat.

• **Oil**

Including oil in the diet has long proved to be beneficiary in hot climates and shows better effects than in moderate climates. For example, the inclusion of oil increased feed intake by 17.2% at 31°C compared to only 4.5% at temperatures of 10-18°C. Digestion of fat produces less heat than the digestion of carbohydrates and proteins. Oil binds the fine particles

Since the bird's skin has no sweat glands, evaporation takes place through panting.

in the feed and stimulates feed intake. Additionally, it increases the energy level in the feed, which is very important to compensate the reduced energy intake due to less feed intake during the hotter periods.

Fat has also been shown to slow down feed passage through the gastro-intestinal tract, and therefore increases nutrient utilisation. Up to 5% oil can be used. An additional advantage of oil is the content of linoleic acid, which improves the production and weight of the eggs.

• Protein

Whether protein levels should be increased or decreased in diets to minimise heat stress and maintain production has been studied with different results. Consensus appears to be that the key to good nutrition is to focus on daily intake of essential amino acids while reducing total digestible protein intake within the constraints of available raw materials.

• Vitamins

Vitamins are unarguably very important components of a chicken's diet. It should also be noted that unless a formulated ration is used, it is likely that deficiencies will occur, negatively affecting the bird (*Table 3*). Vitamin C is thought to support the birds in handling heat stress, but the effects are not yet fully understood. Some birds may not be able to synthesise sufficient ascorbic acid to replace the severe loss of vitamins during heat stress. Research in the early 1960s showed that an addition of vitamin C improved egg weight, shell thickness and egg production. Later experiments demonstrated that adding ascorbic acid in the feed formula improved feed intake and feed utilisation. The optimal effect was shown by adding 250-400 mg ascorbic acid/kg.

Due to the lower feed intake at high temperatures, a sufficient supply of vitamins has to be guaranteed.

Table 3 - Vitamin deficiencies and their negative effects

Fat soluble vitamins	
Vitamin A	Decreased egg production, weakness and lack of growth
Vitamin D	Thin shells, reduced egg production, retarded growth, rickets
Vitamin E	Enlarged hocks, encephalomalacia (crazy chick disease)
Vitamin K	Prolonged blood clotting, intramuscular bleeding
Water soluble vitamins	
Thiamine (B1)	Loss of appetite and death
Riboflavin (B2)	Curly-toe paralysis, poor growth and poor egg production
Pantothenic Acid	Dermatitis and lesions on mouth and feet
Niacin	Bowed legs, inflammation of tongue and mouth cavity
Choline	Poor growth, fatty liver, decreased egg production
Vitamin B12	Anaemia, poor growth, embryonic mortality
Folic Acid	Poor growth, anaemia, poor feathering and egg production
Biotin	Dermatitis on feet and around eyes and beak

Table 4 - The most important minerals and possible effects due to deficiency

Calcium	Poor shell quality and poor hatchability, rickets
Phosphorus	Poor shell quality and poor hatchability, rickets
Magnesium	Sudden death
Manganese	Perosis, poor hatchability
Iron	Anaemia
Copper	Anaemia
Iodine	Goitre
Zinc	Poor feathering, short bones
Cobalt	Reduced hatchability, retarded growth, mortality

• Electrolytes

The electrolyte balance in birds is altered during heat stress due to panting. Panting increases carbon dioxide loss in the bird, which reduces the bird's ideal water intake. By adding electrolytes to the feed or water, birds increase their water intake. This aids in keeping a constant body temperature, and also maintains an effective system of evaporative cooling.

• Minerals

During hot periods, mineral excretion is usually increased. It is therefore advisable to increase the mineral level in the formula. Since it is difficult to react fast enough through dietary changes, application via drinking water is recommended. To meet the calcium requirements of laying hens, additional oyster shells or limestone chips can be offered. ■

** References are available on request*