Management of laying hens to minimize heat stress

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Introduction

Animal production constitutes an important component of the agricultural economy of developing countries, a contribution that goes beyond direct food production and includes multipurpose products and uses, such as skins, feathers, fibre, manure for fertilizer and fuel, power and transportation, as well as a means of capital accumulation and as a barter product in societies without circulation of currency. Poultry production has emerged as a substitute for beef and mutton, with spectacular growth rates throughout the world during the last decade: 23 percent in developed and 76 percent in developing countries, respectively. This increase is due to the introduction of commercial production and has been most notable in the Far East where growth averaged 90 percent. In India, for example, production has increased sixfold in ten years.

People in industrial countries eat about twice as many eggs as people in developing countries-approximately 226 eggs per person per year. Yet only 30 countries are seeing any growth in per capita egg consumption. Among these nations are China, Libya, Mexico, Colombia, Turkey, and India. Elsewhere, egg consumption is either stable or falling. FAO predicts that most future growth in egg consumption will occur in the developing world in places like China, where income and population patterns are still shifting

Table 1: Changing contribution of continents to global hen egg production
(World Poultry Vol 23, No 6, 2007)

Continent	1970	1990	2005
Africa	3.0	4.4	3.7
Asia	23.7	39.2	60.4
Europe	30.9	20.1	16.8
USSR	11.5	13.0	-
NC America	25.3	16.4	13.6
S America	4.3	6.3	5.1
Oceania	1.2	0.7	0.4

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

In order to supply the rising demand of a growing and increasingly urban population, intensive commercial projects are being introduced. An obvious example for this development is Asia. Poultry production has rapidly changed in Asian countries like China, India, Thailand, Vietnam, Indonesia, Japan and Korea. Following the introduction of modern breeds and Western technologies, countries such as Thailand and China have become major poultry exporters, supported by cheap labour and cheap power, inclusion of non-conventional feeds and substantial government support. Poultry entrepreneurs in Asia make use of the high production potential of modern egg and meat strains, follow similar management practices and bio-security as Western countries, compete with one another on the global market and often face the same challenges.

Heat stress is a common problem world wide in poultry production. High ambient temperatures can be devastating to commercial broilers and layers; coupled with high humidity they can have even

Table 2: Productivity of scavenging chickens relative to modern breeds

Parameter	Scavenging village chickens	Commercial chickens
Age at marketable weight (weeks) Age at sexual maturity (weeks)	>24	<8 for broilers <20 for layers
Egg production (eggs/hen/year)	40-60	>250
Egg weight (g)	30-50	>60
Mature weight (kg)	1-1.7	>2
Mortality rate (%)	Chicks >60 Adults 45-100	<20

André Mayer 1997

Table 3: Estimated population of rural poultry in developing countries

Country	Number of rural poultry ('000)	Village poultry as a percentage of national flock
Africa	1 500 000	70
China	2 000 000	50
Côte d'Ivoire	-	53
Ethiopia	53 200	99
Indonesia	187 000	60
Kenya	16 000	70
Lesotho	1 600	-
Malaysia	6 500	13
Myanmar	23 200	85
Nepal	-	90
Nigeria	120 000	80
Pakistan	55 500	42
Philippines	43 000	72
Sri Lanka	2 500	25
Tanzania	-	86
Thailand	120 000	80
Uganda	16 000	80
Viet Nam	196 000	98
Malaysia (West)	6 600	15
Zimbabwe	-	30

Source: Awan (1993)

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. The result is that 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 methods which can be used by the poultry producer to partially alleviate some of the detrimental effects of heat stress on the birds' productivity.

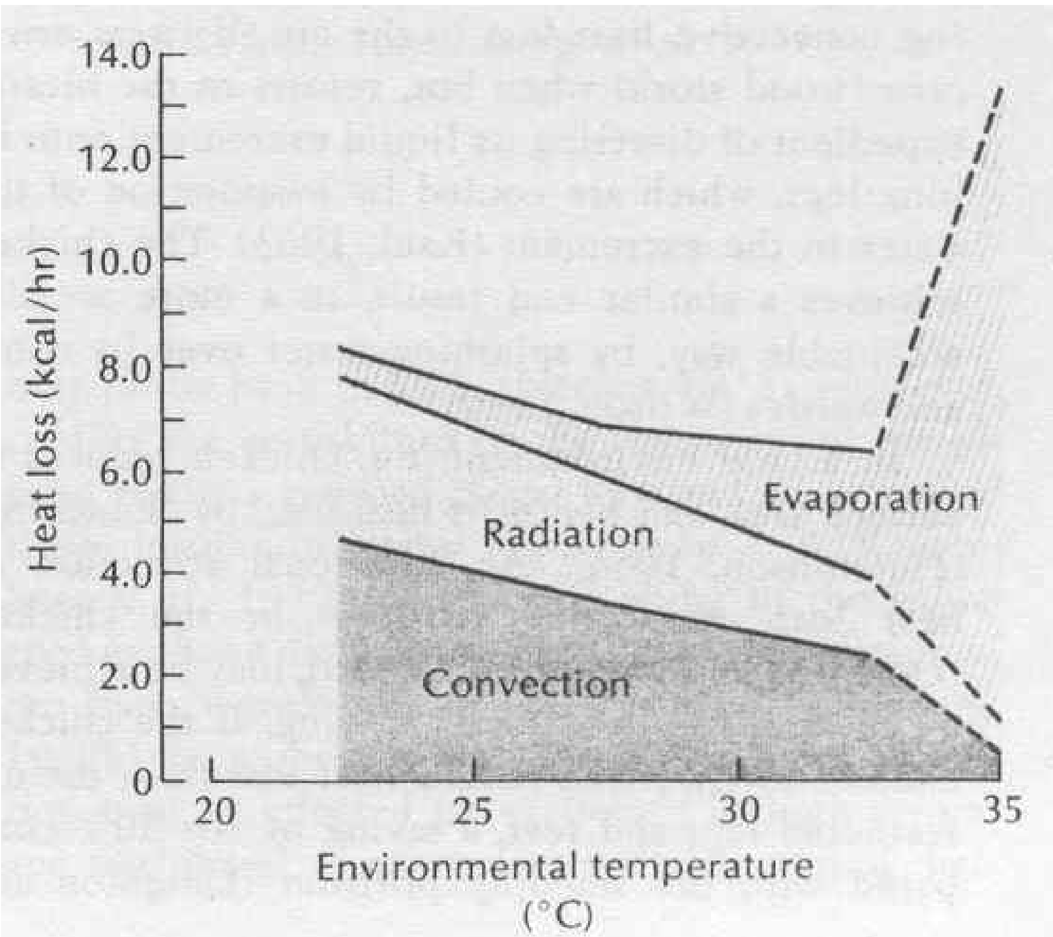
General

The body temperature of a hen varies between 40 and 42°C (Anderson 1997. North 1998). depending on day time (before and after feeding. night time). feather cover in connection with moulting, brooding and environmental temperature – on which we will focus here.

The ideal environmental temperature for chickens is 18-24°C. Above 24°C the bird has a number of possibilities to remove the 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** - heat loss will occur due to increasing air temperature around the hot body. This process can be assisted by providing moving air fast enough to break down the layer of still air surrounding the body.
- **Conduction** - is relatively unimportant. but heat may flow surface to surface e.g. if 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 and 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 Cal, and this energy loss may result in significant drop of production.

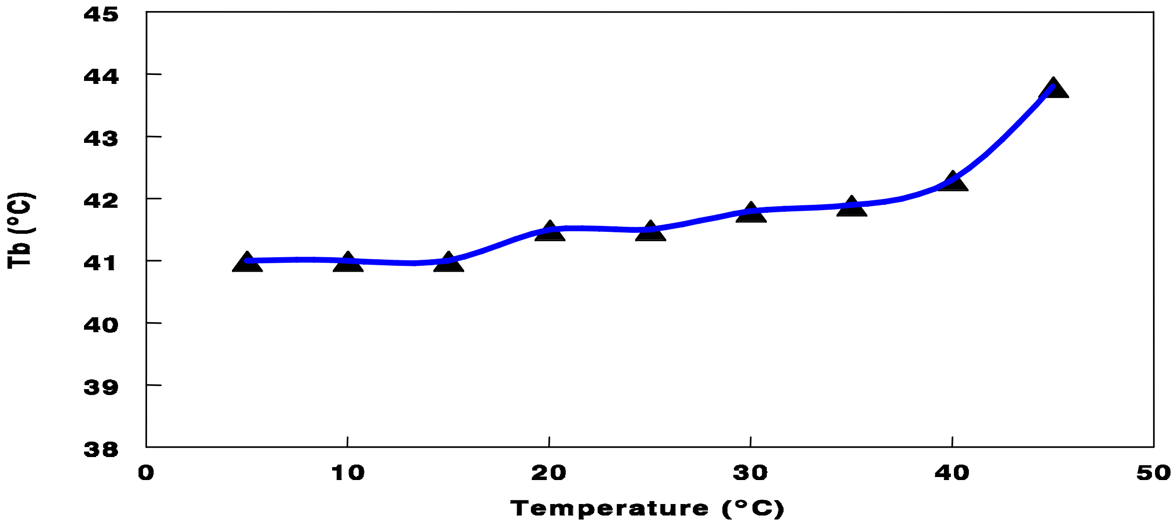
Fig. 1: Radiation, convection and evaporation with increasing house temperature (Source: Whittow, 1976)



Source: Roller & Dale (1962); Deshazer (1967)

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.

Fig. 2:



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

Exposed to 30°C the hen reacts with reduced feed intake, 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 temperature will lead to a decrease of feed and increase of water intake. Water: feed intake ratio at 15°C for example is 1.82:1 while it is 4.9:1 at a temperature between 30-35°C, which is quite a common situation with open houses in hot climates. The following table 2 shows the effect of ambient temperature on production, egg weight and feed conversion:

Table 4: Effect of house temperature on egg production, average egg weight and feed consumption per egg, relative to the optimum of 16° C (Source: North, 1984)

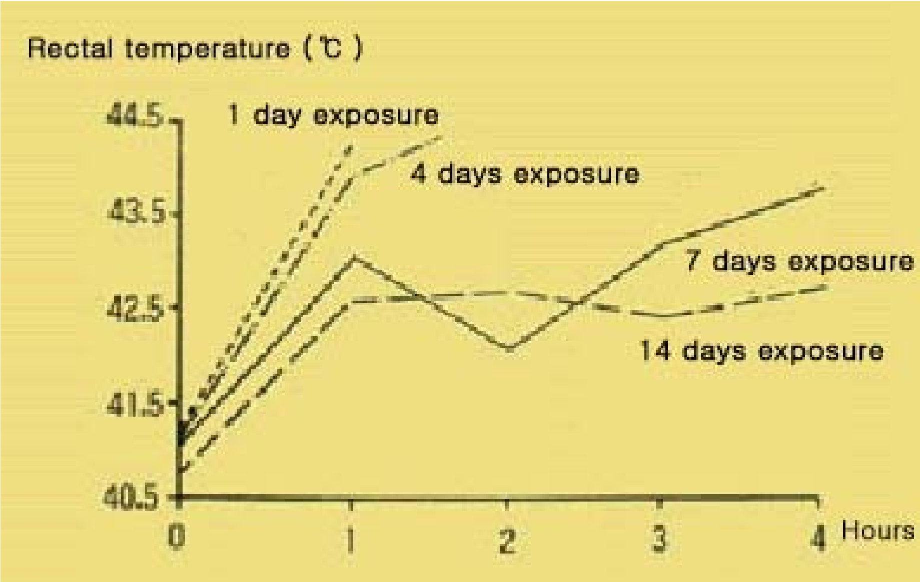
Temp.	Prod.	EW	Feed/egg
16° C	100	100	100
18° C	100	100	95
21° C	100	100	91
24° C	100	99	89
27° C	99	96	86
29° C	97	93	85
32° C	94	86	84

- **Adaptation**

Layers reared at high temperatures from a young age can adapt to some extent and reach good productivity. The hens develop larger wattles and combs and have less fat and feather coverage.

The following figure 3 after Sykes (1983) shows how the body temperature adapts to high temperatures within 14 days.

Fig. 3:



(Sykes. 1983)

Good management practices include attention to the following possibilities to minimize heat stress:

- **Stocking density**

Sensible heat loss depends on the difference between the body temperature of birds and ambient temperature. If stocking density is high, the radiant heat between the birds accumulates and the temperature increases. The birds therefore cannot lose body temperature.

Recommended stocking density with increasing house temperature:

Temp. (c°)	Litter (birds/m²)	Cages (cm²/bird)
25	5.5	450
30	4.5	550
35	3.5	650

- **Bird handling**

During the hot period of the day any additional stress on the birds should be avoided. Vaccination, beak treatment, 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**

Leeson and Summers (2000) exposed layers to an environmental temperature of 33°C. Cool water of 2°C was given to half of the flock and the other group 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.

Birds can reduce body temperature by drinking cool water. Therefore, cool water of good quality should be supplied at all times. This requires that the water tanks are properly insulated. The tanks should be light colored, shaded and filled up to 80% capacity to keep the water cool. Pipes should be insulated and/or buried 1-2 m underground. The lines in the house should be cooled by flushing waterlines 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. Sufficient drinkers have to be available and for nipple drinkers use broiler nipple drinkers.

Changing the acid-base balance of the water through 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 support the birds in coping with heat stress. During late afternoon a significant rise in body temperature can be observed which can kill the birds in severe cases. 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 period. A good strategy to take an unnecessary heat load off the birds is to withdraw feed 8 hrs 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 morning hours. It 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 have to be exactly around midnight, but 3 hrs of darkness before and after the extra 1-2 hours of light is essential to avoid disturbing the lighting program

- **Feed stimulation**

Simple strategies to stimulate feed intake are:

- run the feeder chains more frequently, if necessary empty to avoid overflow.
- the feeders should run empty at least once a day to enhance the appetite and assure that also the fine particles of the feed (premixes, vitamins etc.) are consumed.
- the feed texture should not be too fine; use oil to avoid “dusty” feed.

- **Nutrition**

ME requirement decreases with increasing ambient temperature above 21°C resulting from a reduction of energy requirements for maintenance. The requirement for production is not influenced by environmental temperature. 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 (McNaughton and Reece, 1984).

Digestion of fat produces less heat than the digestion of carbohydrates and proteins. Oil binds the fine particles in the feed and stimulates feed intake and increases the energy level in the feed, which is very important to compensate the reduced energy intake due to less feed intake during heat periods. Fat has also been shown to slow down feed passage through the gastrointestinal 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.

The following table shows the contents of fatty acids in different oils.

Table 4: Fatty acid contents of different sources of fat and oil

Fatty acid	Animal fat	Poultry fat	Bone at	Coconut fat	Palm oil	Rape oil	Soybean oil	Sunflower oil
Laurin C 12:0	0 - 0.2	-	-	48	50	-	-	-
Palmitin C 16:0	23 – 27	20	19	9	7	5	8	6
Stearin C 18:0	14 – 18	8	16	2	2	2	4	4
OiL C 18:1	40 – 60	37	47	7	15	51	28	20
Linol C 18:2	7 - 10	25	8	1	1	24	53	70
Linolen C 18:3	0 - 1	4	1	-	-	6	6	-

Source: IG Fett. Hartfiel

- **Protein**

Whether protein levels should be increased or decreased in diets to minimize 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 very important components of a chicken's diet and unless a formulated ration is used, it is likely that deficiencies will occur. 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. Perek and Kendler (1962, 1963) showed that added Vitamin C improved egg weight, shell thickness and egg production. Experiments of Njoku and Nwazota (1989) 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 sufficient supply of vitamins has to be guaranteed. Vitamin deficiencies can have the following 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

- **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 which aids in keeping a constant body temperature and maintains an effective system of evaporative cooling.

- **Minerals**

During heat periods. mineral excretion is usually increased. Therefore it is 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.

The most important minerals and possible effects due to deficiency are:

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

To meet the Calcium requirements of laying hens, additional oyster shells or limestone chips should be offered.

1. Naturally ventilated houses

In naturally ventilated houses the air has to flow in and out of the house easily. High roofs help to remove heat from the birds. Naturally ventilated houses are usually open. They should be facing in an east-west direction to avoid direct sunlight heating up the building in the afternoon. Direct sunlight increases the effective temperature which the birds feel. The birds will try to move away from direct sunlight, contributing to heat stress due to higher stocking density in the shady part of the house.

- Construction

Natural ventilation is most effective in houses max 12 m wide. The faster the air flows, the more effective will be the cooling. For example: an air flow of 0.1 m/sec has no cooling effect, whereas an airflow of 1.25 m/sec has a cooling effect of 3.4°C (North, 1998). The walls should not be too high so that the air movement can reach the birds.

- Roof

The roof should be insulated to minimise heat absorption and be provided with open ridges (1 m) to allow hot air to escape from the house. Inexpensive locally available insulation materials such as palm leaves, reeds or corn stalks can be used but may attract wild birds, rodents etc..

Instead of good insulation materials such as sprayed polyurethane or polystyrene board, which may be relatively expensive or not available, one can also use simple solutions such as white wash to decrease the heat uptake on the roof. Good mixtures are 10 kg of hydrated lime + 20 l of water or 10 kg hydrated lime + 10 kg of white cement + 25 l of water.

The roof should have an overhang. Properly designed overhangs help to reduce direct and indirect sunlight getting into the house. The taller the side wall and the closer the side wall opening is to the ground, the longer should be the roof overhang. A minimum overhang of 0.6 m is recommended; taller houses and larger curtain openings will benefit from roof overhanging 1.25 m and more.

- Surroundings

The immediate surroundings also have an important effect on the inside temperature of the house. A green lawn around the house kept short and watered will help to reduce reflection of sunshine. Wet grass will also have a cooling effect through evaporation. Small tress can be planted around the house for shade, but they should not disturb the air movement. The temperature difference between shade and sun can be up to 15°C!

All obstacles that hinder air flow should be removed, even cobwebs on the fence.

- Fans

Additional equipment can be installed to control the house temperature. If natural air flow is not sufficient, fans should be installed. Slow speed, large industrial type fans are recommended, installed at 1 m above the ground to blow air horizontally over the birds. It is advantageous to operate the fans also during the night to assist birds to recover from heat stress during the day. The maximum ventilation rate recommended dictates the size and number of fans. As a simple rule of thumb, use 1 x 620 mm 900 rpm fan per 1.000 laying hens.

- Foggers

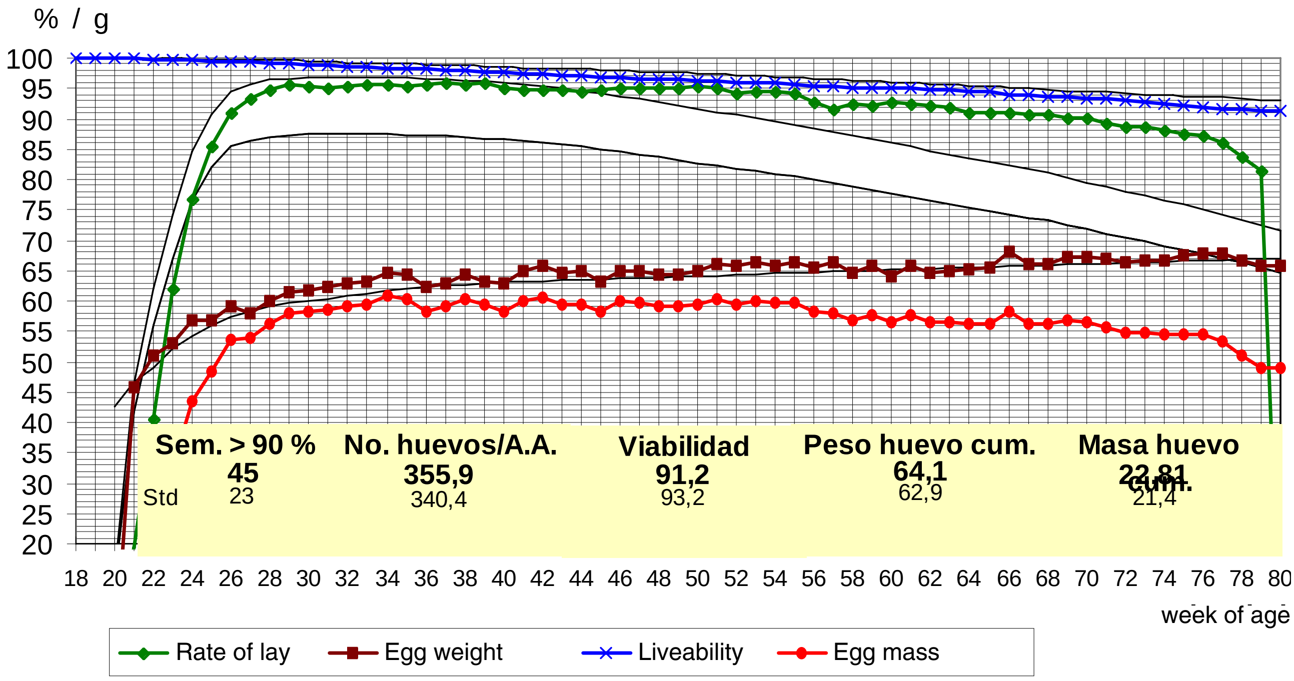
Foggers can help to decrease house temperature; the effect depends on the number of nozzles installed. In open, naturally ventilated houses the rule of thumb is to have a minimum of 0.35l/h fogging nozzle capacity for every square meter of floor space. Fogging should not be started below 28°C and not if the humidity exceeds 80%. Small cycle fogging is better than long cycles (8 sec / 15 sec @ 40% RH) (8 sec / 22 sec @ 70% RH).

- Gunny

The so-called "Gunny" is like a small sister of the cooling pad system - simply a cloth covering a part of the fence. soaked in water through a hose pipe. This simple device can reduce the surrounding temperature by up to 3°C due to evaporation.

Birds kept in open houses can have outstanding results despite high temperature, as shown in the example from South America, documented in figure 4, where the temperature averaged 30°C. These 14.300 LSL layers had only 7% mortality to 75 weeks of age and produced 355 eggs per hen housed, 15 eggs more than the current standard.

Fig. 4: An example for normal production in open housing despite high temperature



2. Power ventilated houses

An alternative to open houses are closed, environmentally controlled houses. They are more expensive in construction and maintenance, but also more effective in controlling temperature. More predictable, consistently high production and reduced mortality should cover the added cost.

Power ventilated houses can have positive or negative pressure systems. The type mostly used in hot climates is the negative pressure system, in which case the air is extracted from the building with fans and enters it through small inlets. Two different negative-pressure systems can be used: (i) the tunnel ventilation system in which the air enters the house at one end of the building and big exhaust fans are located at the other end of the house; (ii) the inlet ventilation system which has several air inlets and fans distributed over the entire building. The tunnel ventilation system is considered more effective in heat management due to a higher rate of air exchange and faster air movement which cools the birds more efficiently.

- Construction

New houses should be properly insulated and have a high standard of construction. Open houses may be transformed into power ventilated houses by closing the side walls with curtains, which requires minimal investment. In case of a power failure or technical problems, it must be possible to open the curtains to switch back to natural ventilation. But curtains do not insulate well and may sabotage the effects of the power ventilation. Roof and walls have to be well insulated.

The airflow has to be sufficient to keep the birds cool. A critical figure is the temperature of the air leaving the house. Transporting the excess heat from the birds, the building and the motors, the outgoing air should not be more than 2.8°C hotter than the outside temperature. The following formula is used to calculate the required air-flow in a power-ventilated house:

Air-Flow Rate = cross-sectional area of the house x required or maximum speed desired.

- Inlets

A minimum of 1m² inlet area per 14.000 m³/h exhaust fan capacity is recommended.
The inlet systems can be differentiated in 3 systems:
(i) cross ventilation (fans on one side of the house. inlets on the other side; works best in houses less than 10 m wide);
(ii) side-wall ventilation (fans and inlets on side-walls);
(iii) attic inlet ventilation (fans are distributed at the side-walls, inlets are in the roof).

- Tunnel ventilation

Tunnel ventilation does not only depend on the right air exchange rate, but also on the air speed. For layers an air speed of 2.5-3 m/s is recommended. The fans can be located either at the end of the building or on the side walls at the end.

3. Evaporation cooling

The principle is based on the fact that humid air contains more thermal energy than air with the same temperature but lower humidity. By spraying water or passing incoming air through cool cells (wet pad), humidity is increased and air temperature decreased. As shown in the following table 5, the cooling effect by evaporation will be best if the humidity of the initial air is low. This system is therefore widely used in desert areas.

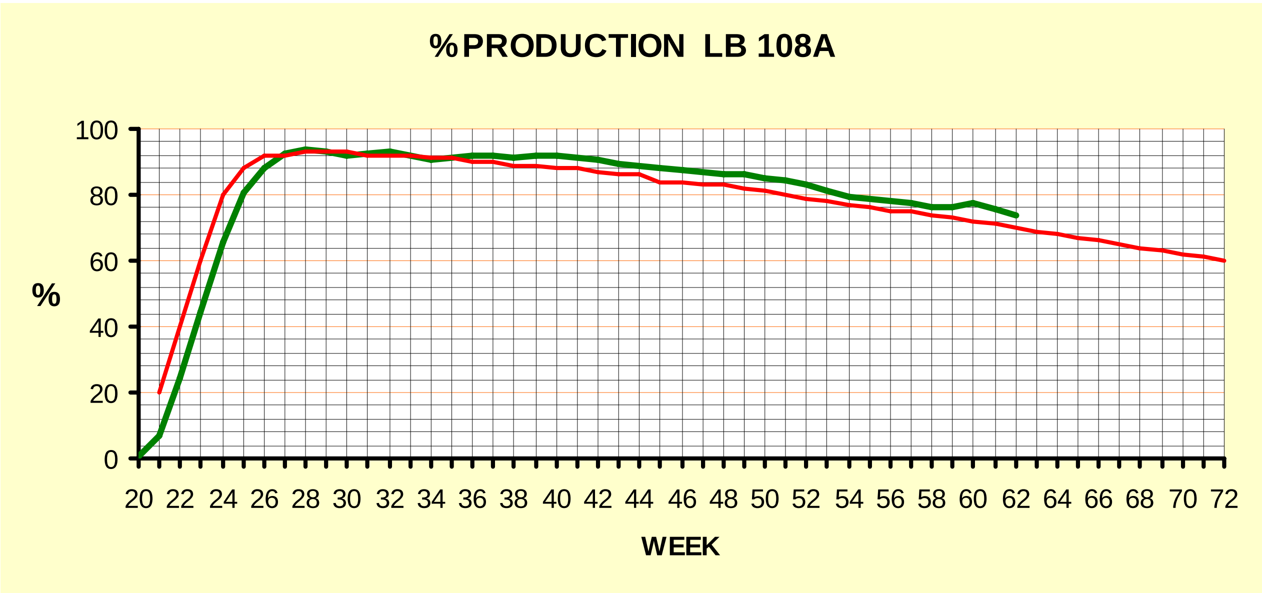
Normally a house with tunnel ventilation is used and the walls opposite the fans are equipped with the cooling pads. Cooling pads have to be in proportion to the fans installed.

Birds placed in environment-controlled houses can achieve outstanding results. Figure 5 shows the rate of production of a LB parent flock in Egypt in a closed 'brown-out' house with a dimension of 30 X 100 m with full litter and cooling pads with exhaust fans. The house is equipped with metal nests for manual egg collection. This parent flock peaked at 94%, produced at a rate above 90% for more than 13 weeks and had cumulative mortality of 6.5 % to 62 weeks of age.

Table 5: Effect of evaporative cooling depending on initial temperature and humidity

Initial temp.	Temp. after humidity increase		
	30% → 80%	40% → 80%	50% → 80%
30°C	20°C	21°C	22°C
35°C	23°C	26°C	28°C
40°C	28°C	31°C	34°C

Fig. 5: Egg production with environment controlled housing in Egypt



Summary

Animal production is an important agro-economic branch in developing countries, in which the poultry economy plays a fundamental role and has largely replaced the production of cow and mutton, above all in Asia. Especially egg production enjoyed a significant increase of per capita consumption in developing and newly industrialised countries like China, Mexico, India, Turkey and Colombia, where local populations were replaced by more efficient modern hybrids.

Intensive poultry production faces many problems, including heat stress, which limits the realization of genetic potential. This article explains what happens if ambient temperatures exceed the optimum range for layers and how the effects of heat stress can be minimized under practical conditions.

The ideal temperature range for layers is between 18-24°C. Above this level, the birds employ different mechanisms to get rid of excessive body heat. Up to 30°C, the hen can regulate body temperature by reducing feed intake (at the cost of egg output, because energy is used for cooling the body). Chickens can adapt to high temperatures to some extent, but from 41°C drastic measures must be taken to avoid mortality due to heat stroke.

The most important measures are:

- special care in designing new houses (location and position, roof construction, insulation)
- special equipment for cooling (pad cooling, ventilators, foggers, roof sprinklers)

- reduced bird density at housing
- cool drinking water
- feeding during early morning and afternoon
- special feed formulation with higher energy (added oil), lower total protein (balanced amino acids) and higher levels of minerals and vitamins
- if necessary stimulation of feed intake (midnight snack)

Strains of laying hens which are suppirior in moderate climates have no problem adapting to open houses with high temperatures, as demonstraited by the field records in figure 4.

In correctly constructed closed houses it should be easy to realize sufficient air movement and cooling the air down to the desired level by increasing humidity with cooling pads and tunnel ventilation. As illustrated with field records of a Lohmann Brown parent parent in Egypt, investments in environment control can pay off in terms of higher and more predictable egg output. If capital is available for investment in closed housing, the expected return on investment should be calculated from the difference between outside and inside temperature, humidity of outside air and the expected income from additional eggs produced.

Zusammenfassung

Managementempfehlungen für die Haltung von Legehennen zur Minimierung von Hitzestress

Tierproduktion ist ein wichtiger agrarwirtschaftlicher Zweig in Entwicklungsländern, wobei die Geflügelwirtschaft eine zunehmende Rolle spielt und vor allem in Asien häufig die Produktion von Rind- und Schaffleisch ersetzt. Insbesondere bei der Eierproduktion gab es einen Anstieg im pro Kopf Verzehr in Entwicklungs- und Schwellenländern wie China, Mexiko, Indien, der Türkei und Kolumbien, wo lokale Rassen durch Legehybriden ersetzt wurden.

Die intensive Geflügelhaltung ist nicht problemlos, insbesondere in diesen Ländern Hitzestress für die Tiere, unter dem sie nicht ihr volles genetisches Potential entfalten können. Dieser Artikel soll den Effekt von Hitzestress bei Legehennen erläutern und Hilfestellung beim Management leisten.

Die ideale Temperatur für Legehennen liegt bei 18-24°C. Wenn diese überschritten wird, hat das Huhn eine Reihe von Mechanismen zur Verfügung, um exzessive Körperwärme abzuführen, wobei mit steigender Temperatur vor allem Verdunstung eine tragende Rolle spielt.

Bis zu 30°C kann die Henne die Körpertemperatur auf Kosten von Eizahl und Größe gut regulieren, da sie die Energie für die Kühlung benötigt und weniger frisst. Hühner können sich bis zu einem bestimmten Grad auch an Hitze gewöhnen, aber ab 41°C müssen drastische Maßnahmen ergriffen werden, um Mortalität zu vermeiden.

Die wichtigsten Maßnahmen sind:

- richtige Konstruktion der Ställe (Lage, Dach, Isolierung)
- zusätzliche Kühltechnik (Padcooling, Ventilatoren, Nebelanlage, Dachberegner)
- geringere Besatzdichte bei der Einstallung
- kühles Trinkwasser
- optimale Futterzeiten
- Futteroptimierung in Anpassung an geringeren Verzehr (Öl als Energiequelle; weniger Rohprotein durch Zusatz limitierender Aminosäuren; erhöhte Vitamin- und Mineralstoffgehalte)
- ggf. Stimulierung erhöhter Futteraufnahme durch „midnight snack“

Dass die in Gebieten mit mäßigen Temperaturen marktführenden Herkünfte auch bei Offenstallhaltung in heißeren Regionen sehr gute Resultate erzielen können, wird an einem Beispiel von Lohmann LSL in Südamerika gezeigt. Geschlossene Ställe mit optimaler Klimakontrolle haben sich in ariden Gebieten bewährt. Ob sich diese Investition im Einzelfall rechnet, hängt nicht nur von der Differenz zwischen der Außentemperatur und der gewünschten Stalltemperatur ab, sondern auch von der Luftfeuchtigkeit der Außentemperatur und dem Verkaufserlös der zusätzlich produzierten Eier.

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