KEY STONE

KEY WORDS TO SERVE ANIMAL HEALTH

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HOW TO UNDERSTAND

HEAT STRESS

AND WHAT TO DO ABOUT IT

Summer 2013

TYPICAL CONDITIONS LEADING TO HEAT STRESS OCCUR WHERE...

Environmental temperatures are 26 degrees C (78 degrees F) or more, and relative humidity is greater than 40%.

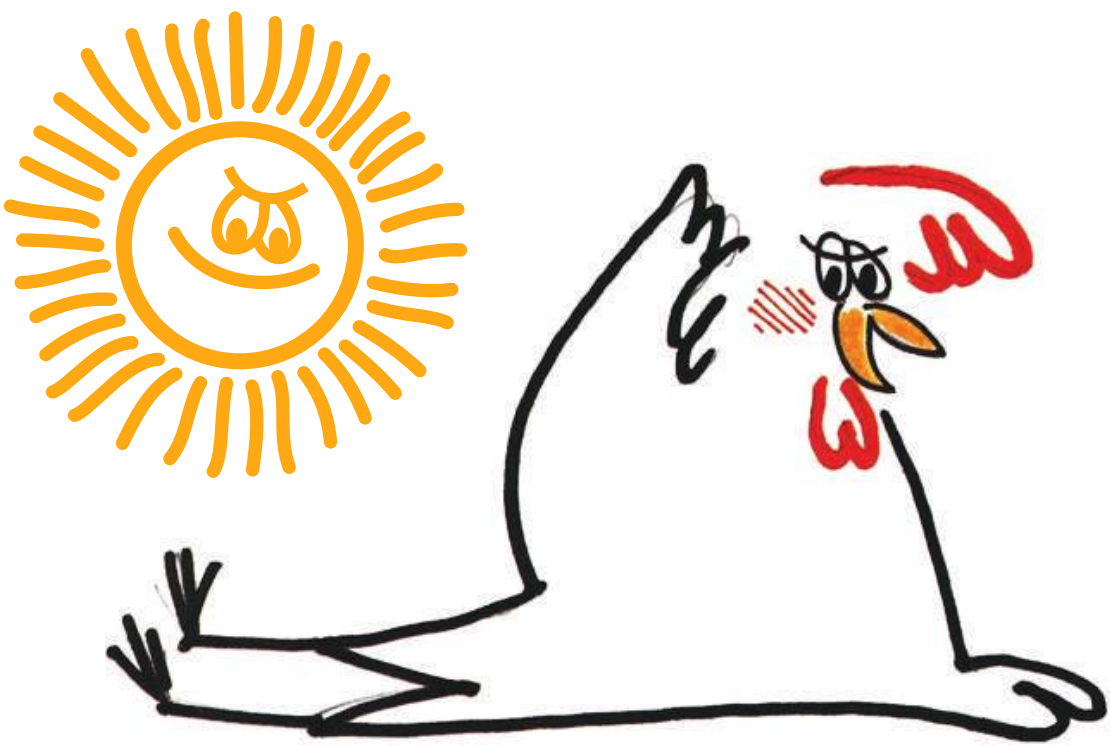
HEAT STRESS IS THE MAJOR CAUSE OF LOST PRODUCTION AND LOST PROFITS

Virtually all birds farmed in hot and humid countries are genetically derived from strains originally

Beacuse most farmers who live in hot and humid climates have not seen such bird's production levels in cool climates, they do not realise how much improvement in productivity is possible.

Any lack of understanding of the effect of Heat Stress is an important source of economic loss.

Good management of Heat Stress is the key factor in successful poultry production in tropical and sub-tropical environments.



HEAT STRESS IN POULTRY

Poultry are homeotherm animals (they can regulate their body temperature - around 41 ºC - by regulating metabolic heat production and heat loss). The body temperature of birds should remain within certain limits to safeguard welfare and maintain production (thermoneutral zone). We can consider that an animal is suffering from heat stress when ambient temperature rises beyond the upper limit of the thermoneutral zone, causing heavy losses due to decreased production and increased mortality.

ENVIRONMENTAL TEMPERATURE	EFFECTS ON THE BIRDS
18 – 24 ºC	Thermoneutral zone
24 – 30 ºC	Slight decrease in feed intake When T approaches 30 ºC → ↓ egg size and shell quality
30 – 32 ºC	↓ Average Weight Gain ↑ Water consumption
32 – 35 ºC	↓↓ Feed intake Prostration
35 – 38 ºC	↓↓↓ Feed intake (1/4 normal feed intake) ↑↑ Water consumption ↑ Prostration
> 38 ºC	↑ Mortality
> 43 ºC	Death before 3 hours

(Quiles&Hevia,2005)

HOW TO SPOT HEAT STRESSED BIRDS

The signs of heat stress are open mouth panting, wing spreading, and squatting close to the ground. By adjusting the position of their feathers, the birds are trying to lose heat. By gasping they are losing water in the breath and cooling themselves by evaporation from the surface of the lungs.(80% of heat is lost this way)

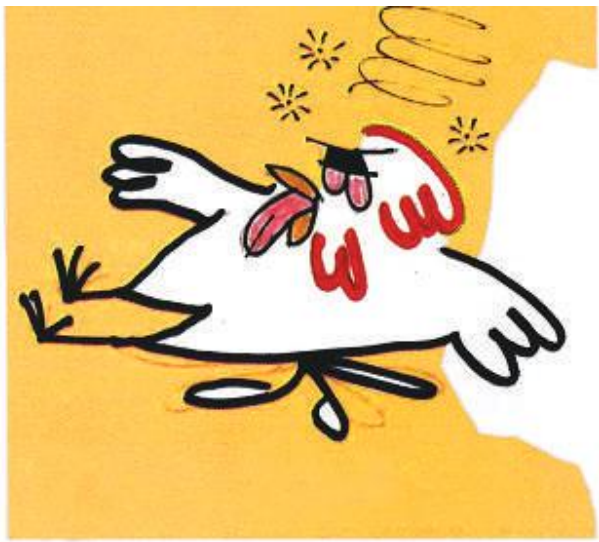
Even if birds are not sick, these are serious matters for the farmer because he knows by experience that production falls in direct proportion to the bird's temperature and discomfort. With no treatment and worsening conditions the birds will die.

At an environmental temperature of 28°C (82°F) appetite is depressed by 12% & where high relative humidity is also present, by as much as 50%.

SIGNS OF HEAT STRESS IN POULTRY

In general, birds will be suffering heat stress when any of the following signs are evident:
Gasping, panting, panting respiration - up to 250 breaths per minute - mediating evaporative cooling from the surface of the lungs (80% of heat is lost this way)

wings spreading Stupor, staggers & terminal convulsions.
Slowness and lethargy.
Increased cannibalism
More carcass down grades.



Light body weight, poor colouring and rough skin.
Egg production drop for no apparent reason
Redused egg size, poorer egg shell quality.
Increased mortality
Increased output of urine - further loss of electrolytes
Wet dropings develop
Thirst increases - many times
Bone metabolism is disturbed e.g. tibial dyschondroplasia

Ascites incidence increases
Immunity to intercurrent disease is lowered
Appetite is depressed, there is some indigestibility of feed and gut motility is slowed. Nutrient deficiencies may occur.
There is loss of body weight

Downgrading of over-fat carcasses
Fertility is lowered
Growth and growth rate are depressed
Replacement pullets are lighter, lay later and lay fewer eggs
Egg weight decreases
Egg downgrades increase
The absorption of minerals is altered
Birds grow unevenly
Force feeding for higher consumption levels leads to greater mortality.
In Breeders, reduced fertility, due to less mating, poorer semen quality and female infertility.

INVISIBLE SIGNS OF HEAT STRESS IN POULTRY

pH of blood plasma rises
pH within the cells falls
Urine output increases and so does electrolytes
Bicarbonate (HCO_3) is lost
Stress hormones appear in the blood
Gene function is disturbed
Resources being diverted to unproductive efforts by the animal (bird) to restore balance (homeostasis)
Heat shock proteins are activated to shut down metabolic reactions and to protect heat-sensitive tissues.
Responses to intercurrent diseases or pathogens decline rapidly.
All production is stopped due to loss of homeostasis

When the body is heat stressed, the bird drinks more and eats less. (Appetite is depressed by 1.5% for each degree of environmental temperature rise above 20°C (68 °F).

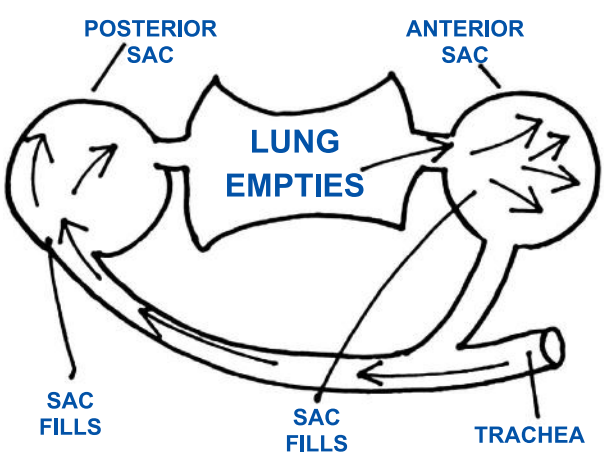
POST MORTEM OF POULTRY SUFFERING FROM HEAT STRESS

When deep body temperature is elevated for prolonged periods, biochemical and physiological changes damage vital body organs such as the heart, lung, liver and kidney.

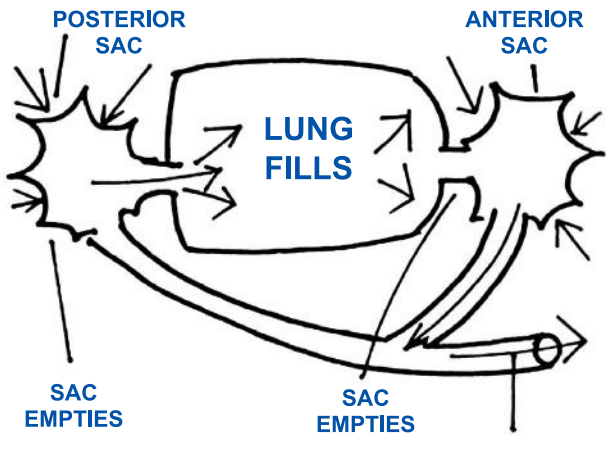
The heart muscle increases in size at the right atrium with significant blood accumulation. Lesions are often present. Congestion and build up of fluids and blood is common. Lesions are often present.
Colour changes to a pale yellow and is congested. Lesions are often present.
Kidney Swells and is inflamed, water blood & urine accumulates.
Muscles are dry and sticky to touch.
Blood is thicker and darker than normal.
Legs are shrivelled and dry.
Crop and gizzard are empty and dry. Gizzard Lining Peels off easily.

HOW DOES THE RESPIRATORY SYSTEM WORK DURING HEAT STRESS

The bird's respiratory system is extensive and complex. Air sacs are attached to each end of the lungs.
The air sacs act as reservoirs and bellows for filling the lungs.
Air flow is through the lung rather than in and out – as in man.
Air flow is counter current exchange of gases, e.g. oxygen (O_2) and carbon dioxide (CO_2), and evaporation of water from the surfaces of the lungs.
The exchange of gases (and vapour) is much more efficient in this system.



BREATHES IN



BREATHES OUT

LOSSES CAUSED BY HEAT STRESS:

- Broilers: ↑ feed conversion ratio (FCR), ↓ weight, ↑ fat carcass content (Belles, 2000), ↑ No. of rejections (Barragan, 2004(2), ↑ mortality rate.
- Layers: ↓ egg production (Barragan, 2004(1), ↓ egg size, ↓ shell quality.
- Breeders: ↓ fertility due to less No. of matings, poorer semen quality, female infertility

More susceptible animals:

Heaviest birds, oldest birds, fast growing birds, best producers, male birds; the birds which produce more endogenous heat.

WHY BIRDS ARE MORE SUSCEPTIBLE TO HEAT STRESS THAN OTHER SPECIES

Birds are more sensitive to heat stress because:

- Birds cannot sweat because they lack sweat glands.
- 95% of their body is covered by feathers, which difficult the dissipation of heat.
- Genetic → decreased ability to lose heat (MacLeod &Hocking, 1993).

MECHANISMS TO ELIMINATE HEAT

1. Radiation:

The skin looses heat by contact with the air (transmission of heat by waves from the hotter environment to the cooler one). There must be a proper ventilation.

2. Convection:

Mode of heat transfer by the natural rise of warm air from around a hot body. The cooler air that contacts the body will become heated and then rise and so on. Birds must be able to stand with wings outstretched.

3. Conduction:

Transfer of heat by contact with cooler surfaces. The body looses heat by contact with beds, drinkers, etc. Difficult in cages.

4. Evaporation:

The hottest molecules overcome the cohesion force that keep them bound to their neighbours and escape, so the average energy of the remaining molecules decrease & the temperature decreases also. Evaporation can occur through respiration (panting), skin (scarce evaporation), dejections (5% of the total).

The first three methods work efficiently without producing heat: they dissipate heat from the body to the environment. Heat eliminated by these three methods is called sensible heat loss. Sensible heat loss increases environment temperature.

When environmental temperature rises upon 28 ºC for broilers (Belles, 2000) and 33-35 ºC for hens (Barragan, 2004 (1), evaporative cooling starts working. Heat eliminated by this method is called insensible heat loss. Insensible heat loss increases body heat temperature by increasing body heat production.

BEHAVIOURAL AND PHYSIOLOGICAL RESPONSES OF BIRDS TO HEAT STRESS

↓ Thermogenesis (heat production), ↑ Thermolisis (heat dissipation)

- Behavioural changes: birds adjust the position of their feathers, spread and drop wings to expose unfeathered areas such as combs and legs (to increase sensible heat loss), reduce physical activity, assume positions in cool places, wet wattles and neck, etc.

- Vasodilatation of epidermal blood vessels allows deep body heat load to be dissipated and decreases digestibility of protein and amino acids (because blood flow is decreased at the proventriculus). Unfeathered areas (legs, comb, etc) have normally less body temperature than feathered areas. Increasing blood flow to unfeathered areas allows higher sensible heat losses.

- Protein digestion and active amino acid absorption in heat-stressed animals is less efficient than in thermal neutral animals. In heat-stressed animals, blood flow to the upper respiratory tract and other organs active in heat dissipation increases at the expense of capillary blood flow to the digestive system. Blood flow decreased more at the proventriculus than at the jejunum and ileum. This would reduce proteolytic enzymatic activities occurring in the upper part of the digestive tract and affects protein digestion (Veldkamp and others, 2002).

- Feed intake is reduced (to avoid heat production caused by digestion), the amount of nutrients available decresase and energy requirements associated with panting increase. Consequently productivity drops. In broilers, for example, body weight decreases and fat carcass content incresases. This lipogenic activity can be considered as a mechanism of acclimatation because fat deposition produces less heat than protein deposition.

- Water consumption is increased to refresh and restore water losses in panting and urine.

- Panting (increased respiratory rate due to a greater oxygen demand and evaporative cooling) causes:
- Dehydration
- When the bird loses the 20% of its water, it dies.
- Increase in hematocrit leads to increased blood viscosity which, in turn, leads to elevated resistance to blood flow. This effect will be greatest in the capillaries, which have the smallest diameter. (MacLeod & Hocking, 1993). This would:
- reduce flow rate through unfeathered areas, such as combs and legs, which would diminish sensible heat loss.
- Reduce flow through lung alveolar capillaries, which would decrease evaporative heat loss.
- Endogenous heat production.
- Respiratory alkalosis, due to a decrease in CO_2 blood levels caused by hyperventilation.

- Increased energetic needs, caused by the muscular activity required to maintain increased respiratory and heart rates.

- The amount of dejections increases, because the excess of bicarbonate (CO_3H^-), caused by respiratory alkalosis, passes to urine pulling other cations, such as Na^+, Mg^{2+} and K^+ together with water.
- Humidity in beds: leads to mechanical problems (skin cracking…) and related pathologies (arthritis, dermatitis, infections…) → increased number of rejections (Barragan, 2004(2)
- Emission of ammonium (NH_3): nitrogen released from dejections associated with humidity in beds (over

35% starts to be dangerous) increases emission of ammonium, which leads to a major susceptibility to respiratory lesions and diseases (Barragan, 2004(2)) → decreased feed intake and growing.
- Losses of electrolytes, which leads to dehydration, shell quality problems, etc.
- Reduced immunological competence, reproductive competence and performance (because the bird is stressed).

Acid-base equilibrium

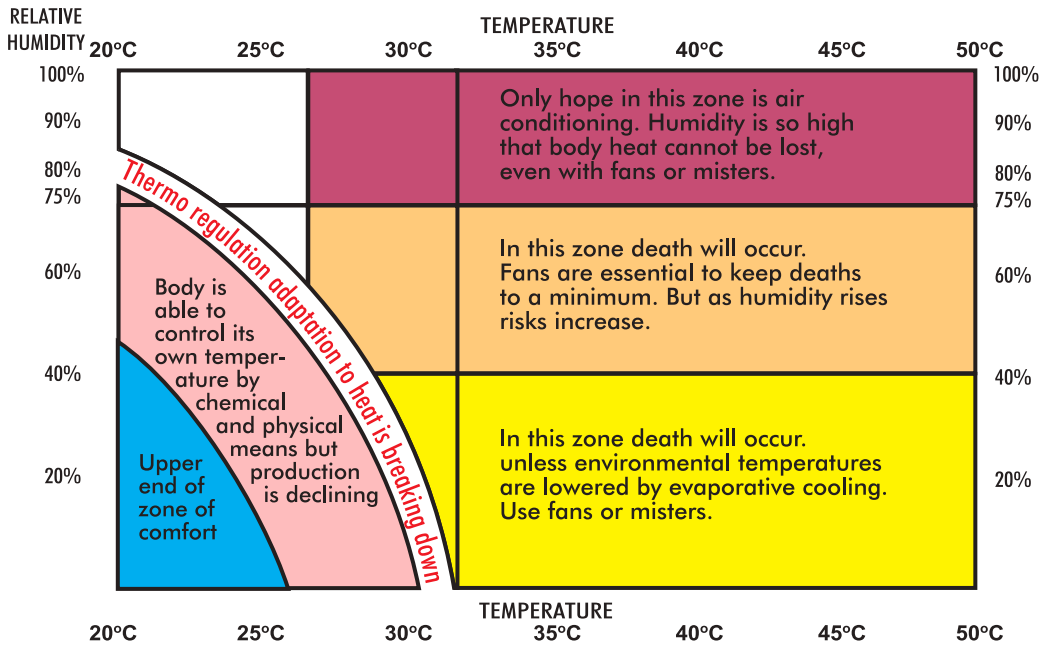
pH is a measure of the acidity or alkalinity of a solution or a measure of the hydrogen ion concentration in that solution.

pH is inversely proportional to the hydrogen ion concentration, so: High pH → ↓ hydrogen ion concentration = alkalosis

Low pH → ↑ hydrogen ion concentration = acidosis

Normal blood pH in birds = 7,33 – 7,45 (neutral) (Campbell, 2004) Ph > 7,45 = alkaline Ph < 7,33 = acid

TEMPERATURE AND HUMIDITY INDEX POULTRY



When temperature moves up QUICKLY, heat stress is much more severe

STRATEGIES AGAINST HEAT STRESS

Factors that modify the response to temperature variations

- **ENVIRONMENTAL FACTORS:**
- Relative humidity: when temperature rises above 28 - 30ºC, high relative humidity worsens heat consequences.
- Air speed inside the shed (insensible heat losses).
- Temperature of walls (sensible heat losses).
- Others: litter, feathers…

BIOLOGICAL FACTORS:

- Age.
- Body weight (heavy birds are more susceptible to heat stress).
- Sex (males are more susceptible to heat stress because of their higher weight, growth rate and consumption. The 75% of casualties due to heat stress are males and their decrease in growth is proportionally higher than in females).

- genotype (lean birds are less susceptible to heat stress).

TECHNICAL FACTORS:

- Management.
- Stocking density.
- Housing.
- Nutrition (excessive dietary protein is detrimental during hot season).

TIME FACTORS:

- Duration of heat stress period (acute or chronic heat stress).
- Acclimatisation (abruptness of temperature change). 12

MEANS TO PREVENT HEAT STRESS

HOUSING

- Orientation: the shed should be constructed with an east-west orientation to avoid direct sunlight falling on birds through windows at midday and to allow good air supply inside the house. Otherwise, it should be constructed with a southeast-northwest orientation to avoid afternoon
sunlight. Orientation is very important in deficiently isolated sheds.
- Sitting: slightly sloping, dry, permeable soil. At a sufficient distance from other farms. If possible, far from cities (specially if the farm is 1500-3000m height, because hot air rises).
- Good insulation
- Good ventilation system to provide oxygen and to remove humidity, heat, dust and unwanted gases such as ammonia (NH3). There are two types:
- natural ventilation: air entering the shed pushes up hot air. It is cheaper than forced ventilation.
- forced ventilation: fans to introduce air from outside and to expel hot air from the shed. The main advantage is that this system provides a better environmental control.
- Materials easy to clean and disinfect.
- Good inner disposal (practical and functional).
- Good quality-price relation of the shed. Two-floor sheds make environment control difficult.
- Specific measures against heat:
- Planting fast growing trees to provide shade to the house and reduce the negative effect of direct heat radiation on the roof and
surrounding air temperature. Trees should not block air entries.

- To provide thermal isolation straw, coconut leaves, palm leaves, empty gunny bags can be spread over the roof.
- Planting green grasses around the house to avoid sunlight reflection to the house. Grasses should not block air entries.
- Build overhangs (50-70 cm) on the roof.
- In natural ventilated sheds: 25% of the floor surface should be window surface. The maximum shed width should be 10 m - 13m.

Management practices to reduce temperature inside the shed (more effective in worse isolated sheds)

- Paint the roof and the walls white: temperature can decrease between 3 and 8 °C.
- Regular watering of the roof.
- Evaporative cooling should be practised with caution under humid conditions: it should be stopped when RH > 80% because then birds can not dissipate heat through panting. There are several systems of evaporative cooling.

Management practices to improve ventilation

- There are several systems of natural ventilation (roof extractors, vertical fans…) and forced ventilation (chimneys, exhaust fans, tunnel ventilation…).
- It should be an homogeneous, uniform, controlled ventilation.
- Heat should be removed during the very first hour at night to allow birds to restore their non-evaporative

cooling potential.

- Avoid obstructions at the entrance or exit of the airflow.

NUTRITIONAL MEASURES

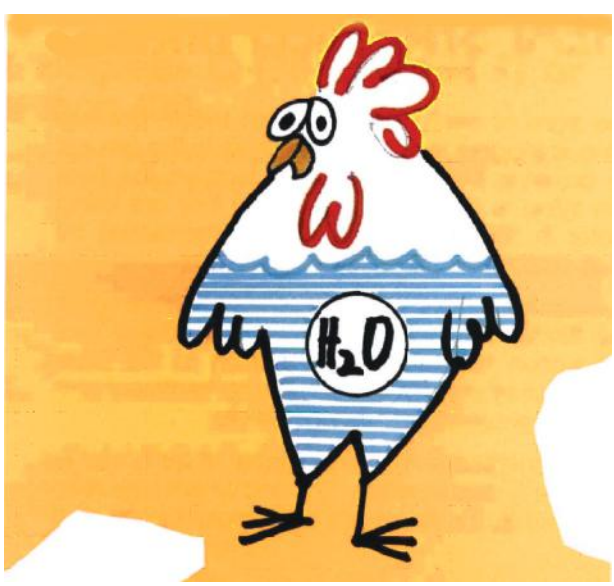
- Stimulate feed consumption: gentle walking during the hottest part of the day will spread the birds and expose them to cooler air and encourage them to drink; continuous lighting programmes, etc. Birds tend naturally to reduce feed intake to reduce endogenous heat production. Stimulating feed consumption can be dangerous for birds and increase mortality rate.
- Make sure that feed do not become rancid in silos during summer months because this can affect palatability.
- Feed intake can be increased by using pellets and good quality coarse ground mash. Do not abruptly change feed presentation.
- Ensure the quality of raw materials.
- Every 10 ºC temperature rises, oxidation and fungal growing increase in the feed. Major levels of antioxidants and inhibitors of fungal growing should be added in the feed.
- Major levels of amino acids (synthetic amino acids) should be added in the feed while protein should be decreased (because protein metabolism generates a lot of endogenous heat). During heat stress arginineabsorption diminishes. Furthermore, a deficiency in lysine causes a rise in body temperature.
- The ratio energy/protein should be increased in the feed. Protein metabolism produces more endogenous heat than carbohydrate metabolism, which at the same time produces more endogenous heat than fat metabolism. Fats can be used as an energetic source because they generate less endogenous heat than carbohydrates and proteins. Besides, 1.6 g of metabolic water are produced by each gram of metabolised fat, which is very helpful against heat stress.
- Sodic bicarbonate (0,20-0,25 % of $NaHCO3^{-}$) can be added in feed one week before hot season starts.
- Vitamin supplements: vitamins do not solve heat stress but some vitamins act as cofactors in several metabolic routes. A lack of vitamins can lead to a deficiency in birds development.
- Group B vitamins: they may have a positive effect.
- Vitamin E: 80-500 ppm. Antioxidant effect on cellular membranes.
- Vitamin C: 30-50 mg /Kg. It acts on the production of adrenal hormones.

3) Management (a balance between strategies to stimulate growing and strategies to reduce mortality should be achieved)

- Reducing stocking density (density = Kg meat / m², not No. of animals) / m²) heat production will decrease.
- Enhancing transport: less time, less stocking density in cages, etc.

ACTIONS ON DRINKING WATER:

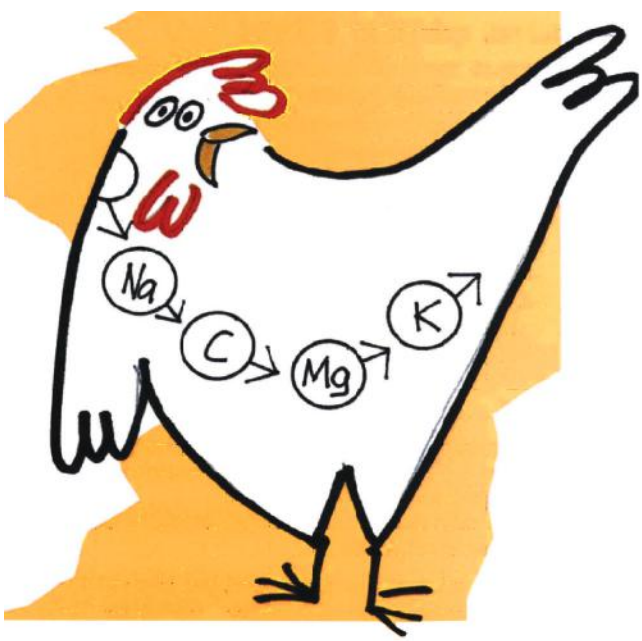
- Make sure that there are enough water drinkers and that they are working correctly.
- Walk among birds to increase water intake (up to 8%) and feed intake.
- Control water quality, chemically and microbiologically (cleaning, chlorination, etc.)
- Take into account that water consumption increases 4% every 0.5 ºC temperature exceeds 21ºC. When water intake rises by 20% upon basal consumption, respiratory evaporative losses increase by 30%.
- Carbonating water or adding acid complements (NH4ClAmmonium chloride, HCl- Hydrogen Chloride) increase water consumption and growth rate.
- Supplementing salts (ClK- Potassium Chloride, NaCl- sodium chloride, K2SO4- Potassium sulphate) increases water consumption and growth rate.

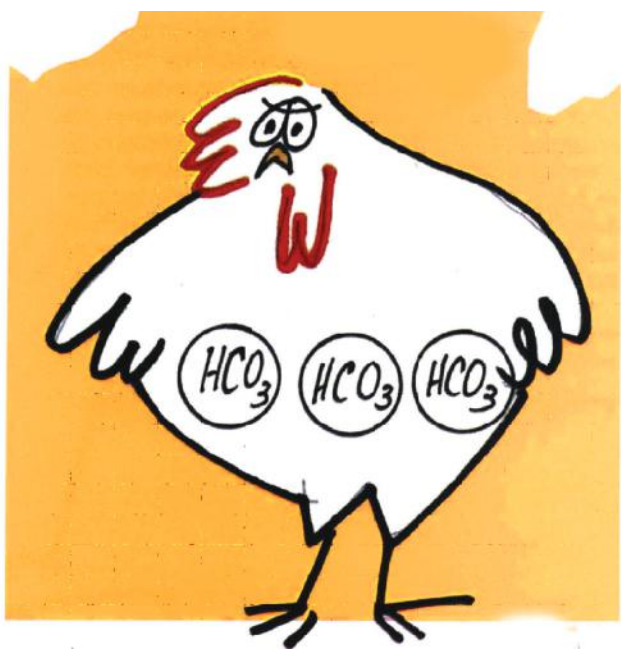


- Supplementing ClK 1,5% in drinking water prevents the loss of potassium (K) due to heat stress.
- Supplementing 0,1% of vinegar increases water consumption and decreases respiratory alkalosis.
- Supplementing sodium bicarbonate 1Kg/1000L increases water consumption.
- Hot water (> 20ºC) diminishes feed intake and growing. Cold water (< 15ºC) increases feed intake (5-10% compared to H2O at 29 ºC). This is possibly due to the fact that cold water in the crop cools the blood that goes to the brain (preventing damage to the respiratory centre) and the blood coming from wings that goes to the heart. There are two systems to keep water cold:

1) insulate pipes or bury them.
2) drain pipes 3-4 times/day.

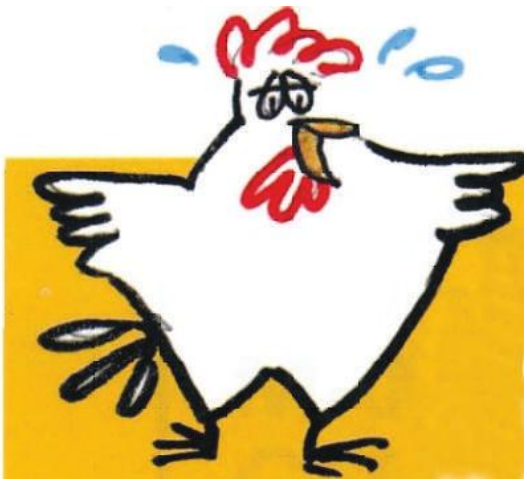
- Other additives supplemented in drinking water to reduce Heat Stress effects:
- Vitamin C: 1g/L (diminishes corticosterone rise due to Heat Stress).
- Multivitamins.
- Electrolytes.
- Acetylsalicylic acid: 0,3 g/L (diminishes body temperature).
- Glucose 4%: regulates blood viscosity and plasmatic osmolarity (skin thermal conductivity depends directly on blood flow to the skin).
- Carnitine + sorbitol + magnesium sulphate: act on lipid metabolism and eliminate the excess of circulating fatty acids, which improves animal health status in front of heat stress.
- Acclimatisation: some studies report that gradual exposition to high temperatures during bird's life improves resistance to heat stress. It is possible that keeping 5-day old young pullets in a situation of acute heat stress improves resistance to heat stress in 40-day old chickens.





- Fasting: the best results are obtained when feed is taken away 3 hours before the beginning of the hottest part of the day. Then the bird's digestive tract has time to empty and substrate availability is reduced, so no heat is produced by digestion.
- Modification of the lighting program: birds are exposed to light during the coolest hours of the day to increase feed intake. At night, temperature may decrease around 10ºC compared to daytime. This allows birds to endure higher diurnal temperatures because they have had time to dissipate heat during the night.
- Hygienic measures in the farm: take away corpses the soonest time possible, control parasites and coccidiosis outbreaks (as feed intake is decreased, consumption of coccidiostatic drugs is also decreased).

4) Information and weather forecast: to be able to adopt the most suitable management measures.

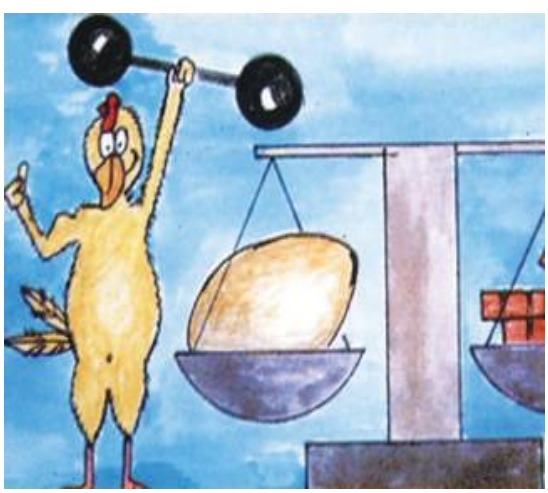


HEAT STRESS, ITS CONSEQUENCES AND WHAT TO DO ABOUT IT

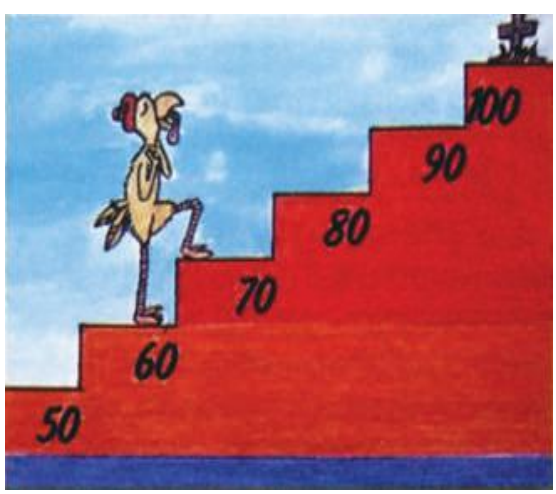
ENVIRONMENTAL TEMPERATURE OF 28°C APPETITE IS DEPRESSED BY ABOUT 12o/o.

Although birds are not sick from any disease. heat stress reduces their production of meat and eggs - sometimes very severely.

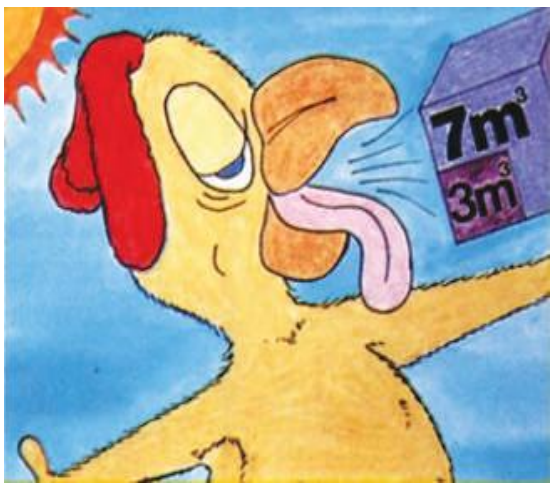
wny is this so. when chickens were first domesticated in South East Asia over four thousand years ago?



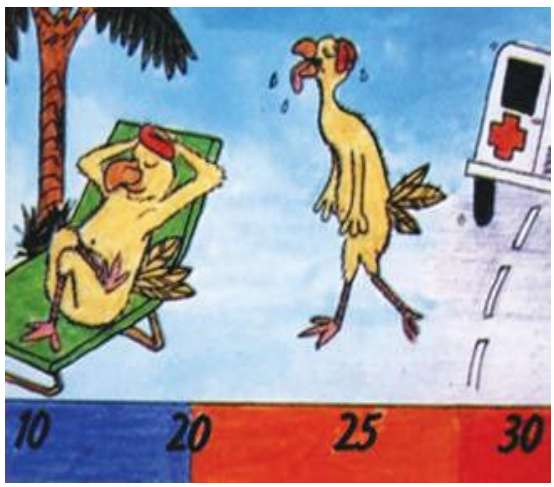
Over the lost forty years, many new hybrid strains of poultry hove been bred. always to give more meat more quickly. or to improve egg production.



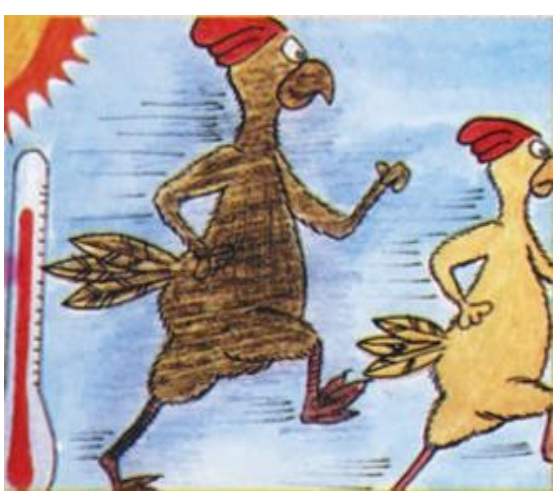
Expired air is fully saturated with moisture, and when the humidity of the air around the bird rises to about 70%,very little evaporation can toke place from the lungs. This means that the birds' main cooling system is in danger. and about to break down.



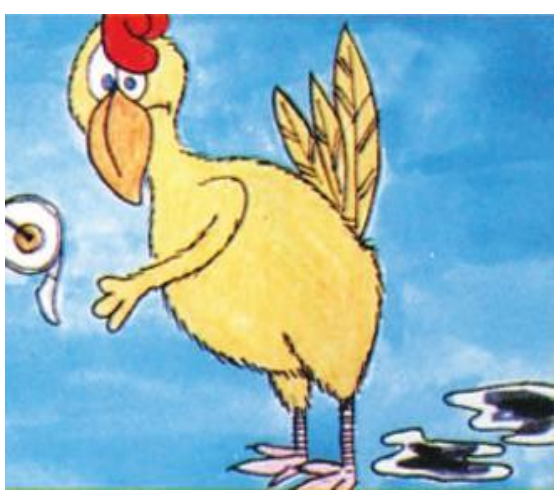
The bird tries to compensate by breathing more quickly. As the humidity and temperature rise. The bird starts to pant and the volume of the breath increases from three cubic metres to seven cubic metres per day. Because muscle activity is increased as the bird pants. The body burns up more energy ... and more healis produced ... so the problem gets worse.



In conditions of high humidity the birds con remain comfortable in temperatures of l0°C to 20°C. Between 20°C and 25°C, symptoms of mild Heat Stress will begin to show. Above 25°C, production will drop severely ... and some help must be provided.

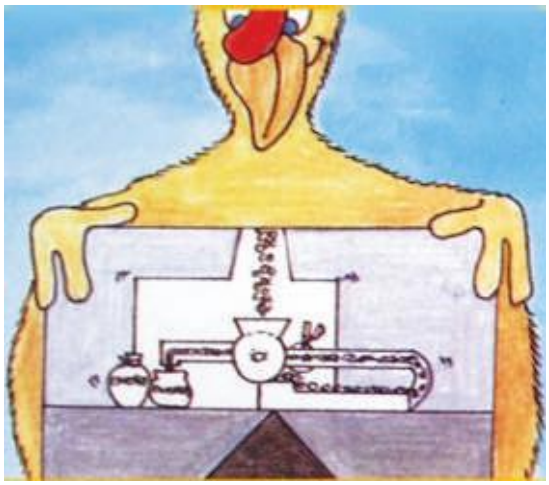


A one degree rise in body temperature means a 20 to 30% increase in metabolism. Since the bird is not eating,it starts to burn up body stores of fat, carbohydrate and protein ... and the bird loses weight.

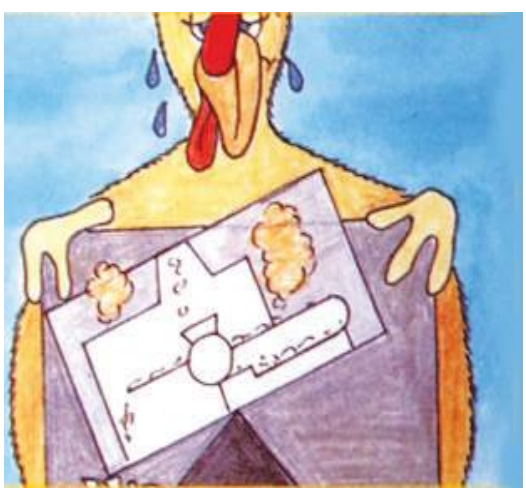


Extra waste products are produced, and these must be removed from the body. The bird drinks more water to wash these waste products away ... and this results in sloppy droppings.

As excessive water is lost in the droppings. the bird loses electrolytes as well. Even a small loss of electrolytes has a bod effect on body chemistry.



A bird is really a chemical factory which converts food into energy: In a normal bird. heat production and heat loss are finely balanced ... and the body temperature is maintained within close limits.

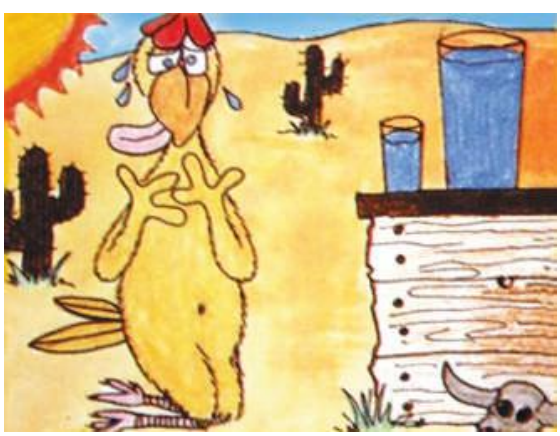


When the environmental temperature rises. the bird itself tends to get hotter ... and has to lose more heat to maintain a constant body temperature.

Most of this heat is lost through evaporation of water from the lungs ... and only a little is lost by convection from the body. The feathers prevent much loss of heat from the skin.

When the temperature exceeds 30°C in conditions of high humidity the birds cannot lose heat fast enough, and the body temperature starts to rise. Birds may adapt to this increased body temperature if the rise is gradual... but they cannot cope with sudden temperature rise.

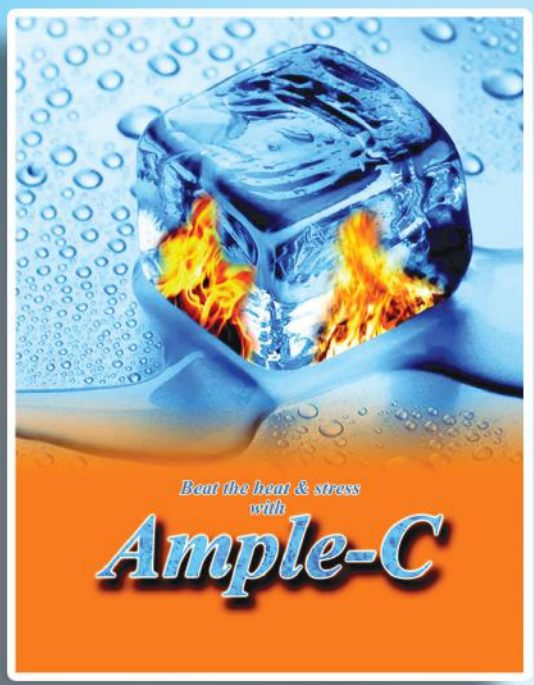
Heavier birds are affected first ... particularly broilers six to eight weeks old. Under the effects of heat stress. respiration changes from closed mouth to open mouth panting ... the birds slow down ... feathers are erect and the wings are outstretched to expose maximum skin surface to the air. The birds stop eating and drink more water.



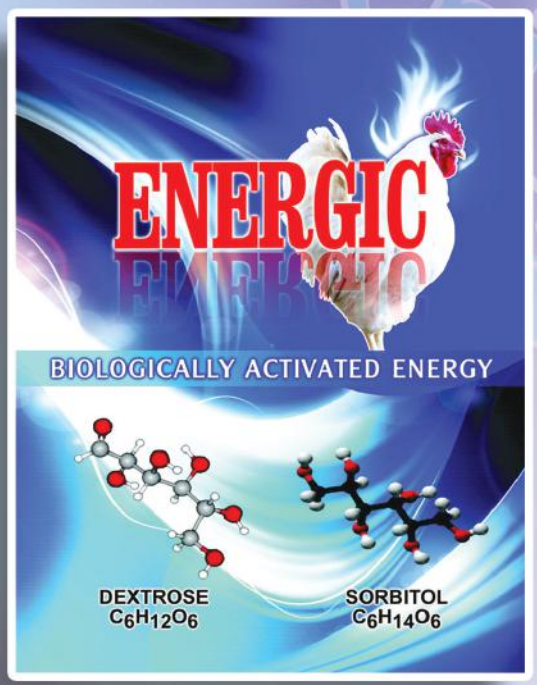
As the body temperature rises further the bird becomes very distressed. and starts to stagger.
Panting becomes very fast. and water consumption increases by 400 percent. When the body temperature reaches 47 degrees the bird dies of heart failure.

WHAT TO DO ABOUT IT

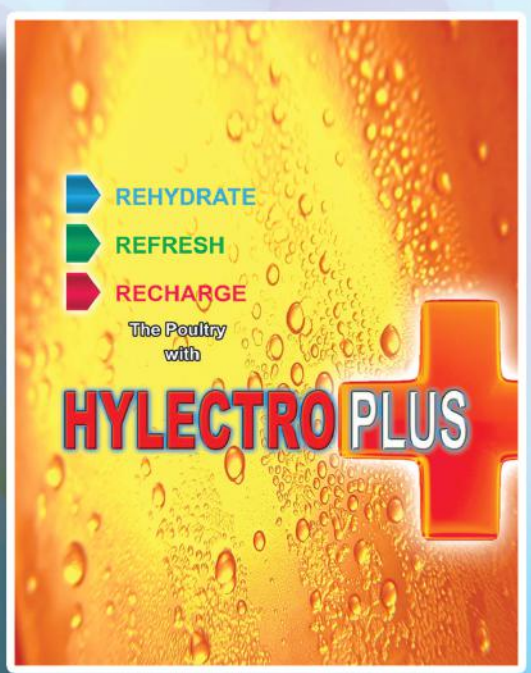
SOLUTIONS



COMPOSITION Per Liter :
Vitamin C 200,000 mg
Propylene Glycol 100,000 mg
Dosage :
50-100 ml per 1000 litre
of drinking water.



COMPOSITION Per Liter :
Dextrose 500,000 mg
Sorbitol 100,000 mg
Dosage :
1,000ml per l,000
liters In drinking water.



COMPOSITION Per Liter :

Natrium Chloride	10,000 mg
Magnesium Sulphate	20,000 mg
Copper Sulphate	10,000 mg
Manganese Sulphate	20,000 mg
Zinc Sulphate	15,000 mg
Iron Sulphate	5,000 mg
Cobalt Sulphate	3,000 mg
Potasium Iodite	1,000 mg
Sodium Selenite	50 mg
Distillate water up to:	1,000 ml

Dosage :
1 ml per 4 liters
of drinking water

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