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HEAT STRESS IN DAIRY COWS

Definition & causes

Metabolic, zootechnical and health consequences

Detection & control strategies

SOLVAY

Progress beyond

Heat stress,

A PHENOMENON MADE WORSE BY CLIMATE CHANGE

Heat stress in dairy cows has many negative consequences for farming. However, according to Météo France projections for the Climalait project, summer temperatures will increase by about 1-2°C by 2040/2060 and the phenomenon will worsen through the duration of the twenty-first century. There is an urgent need to understand the causes in order to adopt strategies to counteract the effects.

Heat stress occurs when animals produce or are exposed to more heat than they can get rid of. As soon as the outside temperature exceeds 20C or the THI (Temperature Humidity Index) exceeds 68, high-producing dairy cows experience heat stress, the effects of which are a deterioration in their well-being, reduced productivity and health risks.

And as herds grow in size, more and more heat is produced inside buildings (CNIEL 2019) and cattle are more likely to experience heat stress.

Note that in the USA for instance, dairy cows experience heat stress 14% of the time. This leads to losses for dairy farming of $897 million every year, i.e. $97 per cow (St Pierre 2003). In light of the growing effects of climate change, this phenomenon must be given urgent attention in order to implement preventive measures.

$897,000,000/YEAR:
THE COST OF HEAT STRESS FOR DAIRY FARMING IN THE USA

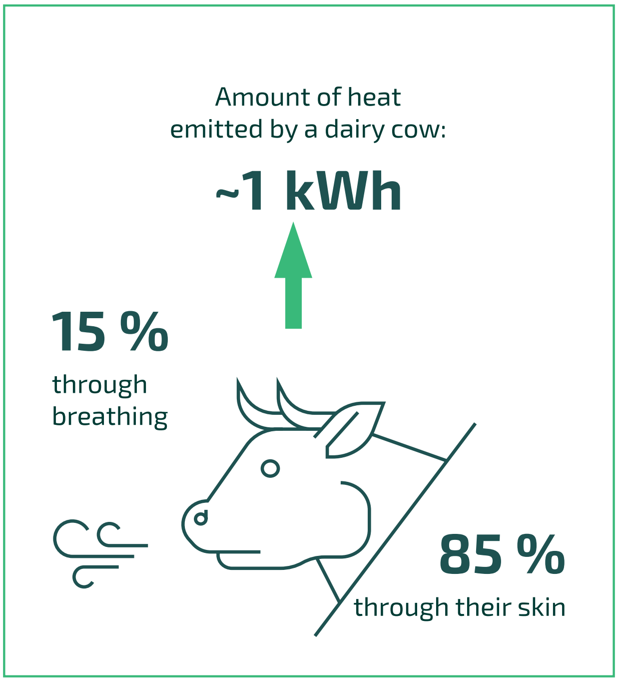
Thermal well-being of dairy cows

A MULTI-FACTORIAL BALANCE

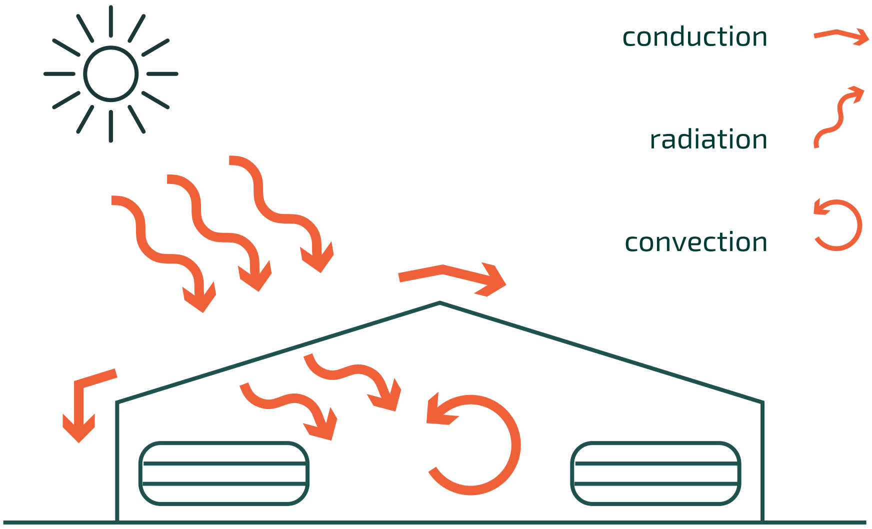
Dairy cows do not tolerate heat well. The temperature they feel depends on a number of environmental factors: their degree of exposure to the sun, the flow, humidity and heat of the air around them, and the heat emitted by the walls and ceilings where they are housed. Ensuring the well-being of animals means establishing their thermal balance and knowing how heat energy is emitted, how it circulates and how it is eliminated in their housing.

THERMAL BALANCE

Dairy cows produce heat themselves from their metabolism, as well as surplus heat from fermentation in their rumen.



The energy emitted comes from breathing and is also released through their skin. With a body surface area of 5-6m² and 100-300Wh released per m², a cow emits about 1,000W of heat every hour.



DAIRY COWS EMIT MORE HEAT WHEN THE AIR SPEED INCREASES AND LESS WHEN THE HUMIDITY INCREASES.

Heat is also generated by radiation from the sun and partitions (walls and ceiling). As far as solar radiation is concerned, black-haired animals, which are more sensitive, absorb 100% of the sun's rays, while red-haired animals absorb 65% and white-haired animals 37%.

The heat of the air plays a key role: **dairy cows emit more heat when the air speed increases and less when the humidity increases**.

Heat is eliminated by conduction, radiation, convection and evaporation. As a reminder, a dairy cow burns 2500kJ (or 600kcal) when they lose one liter of water. One-third of water is lost through panting and two-thirds through perspiration; **cows sweat 8-9l/d at standard temperature, but this increases considerably to 18-24l under conditions of heat stress**.

THE THI: AN INDEX FOR ASSESSING THE THERMAL COMFORT ZONE

According to the authors, the minimum and maximum temperature values of the thermal comfort zone of dairy cows are as follows:

- Between -4°C and +18°C (Adams - PennState)
- Between -5°C and +20°C (Bonnefoy and Noordhuizen 2011)
- Between -5°C and +24°C (Collier 2012)
- It should be noted that the higher the productivity of a cow, the more heat it will give out; **the maximum thermal comfort level is therefore lower for high producers** (Collier 2012).

The THI or Temperature Humidity Index takes into account not only temperature but also humidity. It is calculated from an equation based on temperature and humidity. For example, an air temperature of 22°C and humidity of 50% corresponds to a THI of 68 (Table). This corresponds to the upper limit of thermal comfort for high-producing dairy cows (Collier 2012). In calves, the comfort level is lower, at around 65.

THI*: based on the temperature and humidity *: Temperature Humidity Index		Humidity, as a percentage.													
		30	35	40	45	50	55	60	65	70	75	80	85	90	95
Temperature in degrees Celsius	22	67	67	67	68	68	68	69	69	70	70	70	71	71	72
	23	68	68	69	69	69	70	70	70	71	71	72	72	72	73
	24	69	69	70	70	71	71	72	72	72	73	73	74	74	75
	25	70	70	71	71	72	72	73	73	74	74	75	75	76	76
	26	71	72	72	73	73	74	74	75	76	76	77	77	78	78
	27	72	73	73	74	75	75	76	77	77	78	78	79	80	80
	28	73	74	75	75	76	77	77	77	78	79	79	80	81	81
	29	74	75	76	77	77	78	79	80	80	80	81	82	83	83
	30	76	76	77	78	79	79	80	81	81	82	83	84	84	85
	31	77	77	78	79	80	81	81	82	83	84	85	86	86	87
	32	78	79	79	80	81	82	83	84	85	86	86	87	88	89
	33	78	79	80	81	82	83	84	85	86	86	87	88	89	90
	34	80	80	81	82	83	85	85	86	87	88	89	90	91	92
	35	81	82	83	84	85	86	87	88	89	90	91	92	93	94

THI values which the animal can tolerate

THI values which are dangerous for the animal

THI values which are very dangerous for the animal

Metabolic, zootechnical and health consequences

IMPORTANT RISKS ARE RELATED TO HEAT STRESS

During heat stress, changes in a dairy cow's body temperature and breathing rate have many adverse effects on their health, behaviour and productivity.

THE IMPACT ON METABOLISM

- Under normal conditions, their breathing rate (polypnoea) is 15-35 breaths per minute, but it increases with the apparent temperature. The threshold of 60 breaths per minute is considered an indicator that the cow is under heat stress. **On average, the breathing rate increases by two units per minute and per THI unit;** when it exceeds 200 breaths per minute, the animal's life is in danger. In severe cases of polypnoea, cows drool and the amount of saliva loss can reach 18 litres a day.

60

BREATHS/MIN: THE THRESHOLD FOR HEAT STRESS IN COWS.

- **The temperature of a dairy cow rises**, which can be checked by measuring their rectal or vaginal temperature, and/or an increase in their skin temperature above 35°C.
- In turn, the **rumination time is reduced by 10-20%**.
- **Blood parameters are altered:** polypnoea causes an increase in carbon dioxide (CO_2) released by the lungs, which leads to a decrease in the level of CO_2 in the blood (hypocapnia), which in turn leads to a decrease in blood bicarbonate (HCO_3^-) and the elimination of HCO_3^- through urine; as a result, the availability of bicarbonate for saliva is lower, reducing the return of salivary buffers and rumen pH regulation.
- **The risk of rumen acidosis increases** due to the decrease in rumination time, blood bicarbonate levels, as well as the loss of sodium in the urine.
- **Thermoregulation leads to increased energy requirements.** The drop in ingestion only accounts for 50% of the energy deficit, as the rest is due to overconsumption as a result of metabolism.

THE ZOOTECHNICAL CONSEQUENCES

Heat stress severely affects farming. The following was noted in particular:

- **Ingestion decreases;**
- **Water intake increases**, resulting in an increased volume of urine, resulting in the loss of sodium (there is also more competition around water points);
- **Milk production decreases** in proportion to the THI;
- **The butterfat content and protein content of milk decreases**;
- **Fertility and the fertility rate decreases;**
- **Activity and movement decreases;**
- **Well-being deteriorates** (the amount of time spent standing increases which affects the time spent lying down); in one trial, when the THI increased from 56 to 74, the time spent lying down decreased from 10.9 to 7.9h/d and the time in aisles increased from 2.6 to 4.5h/d
- **Milk production decreases,** not only **in female offspring of dry cows** but also **in their offspring's female offspring**.

HEALTH PROBLEMS

- Increased incidence of **clinical mastitis**
- **Increased cellular levels**
- **Rumen acidosis** and its consequences
- **Lameness**
- **Damage to the intestine,** which becomes permeable ("leakygut") to toxins and bacteria
- **Reduced immunity**
- **Increased risk of abortions, non-delivery, calf disease in dry cows**
- Increased risk of **mortality**

Detection and control strategies

A RANGE OF TOOLS ARE AVAILABLE

In an era marked by climate change, it is more necessary than ever to have the means and strategies to anticipate, detect and reduce the effects of heat stress. There are several possible approaches, both in terms of nutrition and housing.

HEAT STRESS DETECTION

In their housing, it is vital to take measurements in several places. This is because temperatures or the THI measured outside the building do not indicate how the animal feels in its environment.

Two main methods are used in practice:

- **The THI using continuous sensors**
- **The HLI or Heat Load Index:** a technique from New Zealand that takes into account all the parameters influencing heat stress (Gaughan et al. 2007, CNIEL 2019)

In animals , the criteria used are as follows:

- **breathing rate higher than 60 per minute**
- **skin temperature above 35°C** measured with a thermal camera
- **body temperature above 38.9°C**
- **declines in production, rates and ingestion**
- **behavioural changes:** increase in time spent standing, huddling around cool areas, or looking for air streams

DISTRIBUTE 250 GRAMS OF SODIUM BICARBONATE PER DAY, IN ORDER TO OBTAIN A DIETARY CATION ANION BALANCE (DCAB) OF 250 TO 400 mEQ/ KG OF DRY MATTER

NUTRITIONAL STRATEGIES

- **Increase the sodium level to at least 0.4% of the ration and the dietary cation anion balance (DCAB) to 400mEq/kg of dry material.** In practice, this means incorporating 250 grams of sodium bicarbonate and more as needed; ensure that potassium is at least 1.5% of the dry material ingested
- **Keep fresh, clean water near feeding points and the milking parlour,** ideally with 20-25cm water troughs for each cow; ensure troughs are cleaned once a day
- **Feed in the evening rather than in the morning** (so that animals get rid of excess heat during cooler hours), **split meals, lower the dry matter content of rations** (by adding water if necessary), **increase the energy density and ensure a good protein balance**
- **Incorporate short fibres,** in a sufficient quantity, but not in excess, which are well consumed, and not sorted
- **Eliminate hot food** and waste
- **Incorporate live yeast**
- **Incorporate niacin**, which increases vasodilation and lowers body temperature

CONTROL STRATEGIES IN HOUSING

Existing buildings must be outfitted to reduce the impact of heat stress. In the case of new buildings, an overall reflection is essential.

The principles are as follows:

- **Give priority to a high level of air circulation** in the buildings; aim for horizontal, cross flow circulation (a "wind" effect); in hot weather, the objective is to have as few walls as possible; movable partitions (inflated, rolled up, mobile) are preferred in order to manage changes between summer and winter
- **Provide shade on pastures;** graze only at night and bring animals in during the day (provided the building is suitable), cover outdoor calf pens with a roof
- **Use ventilation (from 20°C)**, **if necessary use misters or sprinklers**, combined with ventilation, to cool cows in the holding areas
- **Install insulated roofs,** which prevent heat transfer through sheet metal or asbestos cement, the temperatures of which can reach 60°C.

Care should be taken to implement **these measures for dry animals and heifers** and to **maintain strict hygiene** (bedding area, scraping of aisles, etc.).

Conclusion

HEAT STRESS: A CHALLENGE FOR THE FUTURE OF FARMING

Heat stress, like other forms of stress, adversely affects the health, well-being and productivity of dairy cows.

Climate predictions for the coming years make it likely that heat stress will become more frequent.

Preventive measures must be implemented in farming, particularly in relation to nutrition and housing.

Despite the trend towards an increase in episodes of heat stress, effective control measures can be put in place.

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