Heat stress is the physiological response of an animal to an environment which is outside, specifically above, its thermal neutral zone. (Najar et al. 2011) This creates a condition where the cattle produce more heat than they can dissipate. This largely happens due to cattle having a very small surface area to volume ratio and underdeveloped sweat glands which make it hard for the cows to shed heat. (West 2003) A great portion of the heat produced comes from metabolic heat produced by consumed roughage or in other words is due to the feeding behaviour of the cows. (Kanjanapruthipong et al. 2015) Feeding behaviour then goes on to affect milk production and yield. (Corazzin et al 2021) The study of milk production and yield can make a big difference for farmers. We aimed to answer the question of how does heat stress affect feeding behaviour in cattle?

How do we measure heat stress and feeding behaviour?

The most well known and widely used ways to measure heat stress are measuring a cow's body temperature and the temperature humidity index (THI). (Kanjanapruthipong et al. 2015) These measurements have been found to be good parameters for determining heat stress but they are especially important measurements because they can be used universally and help compare the heat stress of cattle in a variety of different locations and climates. (Salem et al. 2010) Although great for comparisons these measurements are not the best at quantifying the level of heat stress but rather just put cows into one of two groups, under heat stress or non under heat stress. Other parameters such as respiratory rate (breaths/min), heart rate (beats/min), oxygen consumption (VO_2), vaginal temperature (°C) (Ominski et al. 2002) and rectal temperature (°C) have been used to measure heat stress and are better than TMI and body temperature at quantifying the exact level of heat stress. (Arieli et al 2004) This is effective because we are able to measure a variety of physiological parameters. Finally, arguably the best measure of heat stress is heat production (kJ/kg). (Arieli et al 2004) The definition of heat stress is that the cow is producing more heat than it can dissipate and measuring heat production is the measurement that can quantify this the best. (West 2003) Quantifying heat stress is important but ultimately we are more concerned with what causes heat stress and how to stop it.

Feeding behaviour is seen as one of the main contributors to heat stress in cattle. Feeding behaviour covers a wide range of behaviours in cattle but most, if not all of them have a correlation to heat stress and are thus worth measuring. (West 2003) The most widely used feeding behaviour parameters are dry matter intake and nutrient intake. Similar to temperature humidity index for heat stress, dry matter intake and nutrient intake allow us to compare a variety of different foods taken by different cattle in differing climates relatively equally. (Najar et al. 2011) Other measurements of feeding behaviour include eating rate (kg/min), feed intake (kg DM/ meal), meals/ day, meal duration (min), eating phase (min/ day), day feeding time (%), and night feeding time (%). (Kanjanapruthipong et al. 2015) All parameters of feeding behaviour generally revolve around how much and when cattle eat.

To observe cattle and take measurements most experiments and trials were designed similarly as it has proved to be the best way to measure cattle without disturbing or influencing them. (West 2003) In most if not all cases cattle were divided in two groups. In the first group cattle were subject to no different treatment from their everyday lives and feeding and heat stress parameters were measured. In the second group one aspect of the cattle's feeding routine or heat stress exposure was changed. (Skonieski et al. 2021) This may include changing an aspect of a cow's diet such as the nutritional profile of it or changing the amount of shade that cows have available to them. By making small changes such as these, researchers are able to measure the effect that the change and only the change makes with no external factors playing a role.

How does heat stress affect feeding behaviour?

The effects of heat stress on feeding behaviour has been studied extensively over the past few decades and most discoveries have built off one another. Research on the topic started broad, aiming to characterize what heat stress is and how it would affect the general parameters of feeding. These results found important statistics such as cattle should be exposed to an optimal temperature of -0.5°C to 20°C for cattle to increase feed intake and milk productivity (West 2003), or they should maintain a dry matter intake of approximately 24kg/ day. (Arieli et al. 2004) They also found many important correlations that fueled future studies such as a negative correlation between heat stress and dry matter intake as well as heat stress and milk yield. (West 2003) In terms of numbers they concluded that heat stress decreased dry matter intake by 29% and decreased milk yield by 33%. (Shwartz et al. 2009)

After this period of characterizing heat stress and feeding behaviour, from around 2010 to present day research has moved to testing the results of changing various feeding variables and measuring the results. The variables include changing the fiber characteristics or nutrient profiles of the food the cows were receiving, the areas they are allowed to graze in, the amount of shade they are exposed to, and the sizes of their food particles. (Kanjanapruthipong et al. 2015 & Miller-Cushon et al. 2019) A few studies found that eating rate was 10% faster and meal duration was 20% shorter when cows were fed non forage fibers such as soy hulls instead of wheat suggesting non forage fibers reduce feeding costs and improve feeding behaviour. (Arieli et al. 2004) Another study has found that cows preferentially eat larger food particles that increase nutrient uptake when under heat stress. (Miller-Cushon et al. 2019) Overall, all studies have found a negative correlation between heat stress and feeding behaviour. Decreasing feeding behaviour causes a decrease in milk yield and overall cattle wellbeing which has a negative impact on the farmers raising these cows. (Najar et al. 2011) So it is clear that cost effective methods to reduce heat stress need to be studied. This was all done in the hopes of finding the best way to mitigate heat stress in cattle.

Ways to reduce heat stress

Many methods for reducing heat stress in cattle have been studied but these methods are only effective if they are of benefit to the people that may want to use them. The people mentioned above are primarily farmers and for these methods to be effective they have to work well and be cost effective. This means that the cost of reducing heat stress has to be less than the money gained from increased feeding behaviour. (West 2003) The main methods that farmers can implement to reduce heat stress are shading which can reduce total heat load 30%-50% and increase milk yield by 9%, evaporative cooling systems for dairy and dry cows which reduces body temperature by up to 1°C and increased milk yield by up to 19%, nutritional selection such as implementing non forage fibers in place of forage fibers and genetic selection where black cows were up to 58% better at reflecting heat. (West 2003) Out of these methods evaporative cooling has proven to be not cost effective but the rest have shown major benefits for farmers. Shading may include planting trees that provide a lot of shade in grazing pastures or making large metal structures similar to umbrellas. (Skonieski et al. 2021) Nutritional selection may include replacing 25% of feed with non forage fibers, supplementing cows with yeast, or getting foods with larger particles. (Arieli et al. 2004) Finally genetic selection may be hard for farmers to manage but if the idea of looking for darker cows is kept in mind when buying cattle this can help. (West 2003)

Cattle like all other mammals have an optimal set of conditions that they should be at for them to be living in best health possible. If farmers can keep their cows at these levels they will see the greatest improvements in feeding behaviour, milk yield and overall health. Studies have found the optimal physiological and dietary parameters of cattle to be as follows. The respiratory rate of cattle should be approximately 81.18 breaths/mn. (Ominski et al. 2002) The rectal temperature should approximately be 39 degrees celsius. (Corazzin et al. 2021) The heart rate should approximately be 78.87 beats/mn. (Shwartz et al. 2009) Dry matter intake or DMI should approximately be 18.19 kg/d. (Ominski et al. 2002) In terms of nutritional profile crude protein should approximately be 16%. total insoluble fibers should approximately be 32.66%, and cellulose and lignin should approximately be 23.64%. (Ominski et al. 2002) Most of these are hard to measure but certain aspects such as dry matter intake and heart rate can be easy to measure and good indicators to help maintain low levels of heat stress.

Plans for the future

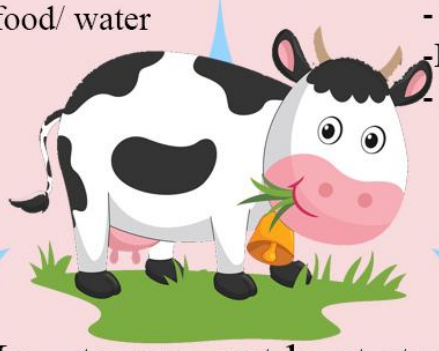
In the future, studies seem to be focussing a great deal on nutrient intake and supplementation. This may include studying Na^+ or K^+ supplementation (West 2003) or finding the effects of different sources of fiber such as other non forage fibers (Corazzin et al. 2021) or finally studying the effects of different shading materials or set ups. (Skonieski et al. 2021) The research in this area has progressed quite far and it will be exciting to see how it can be optimized further. Overall, if farmers are able to implement strategies to reduce heat stress in cows they will see greater milk yields and at the small cost of improving their cattle's wellbeing they will see increased profits down the line. (West 2003)

What causes heat stress?

-High temperature
-Being too close to hot concrete/ floor for too long
- Not having enough food/ water

Signs of heat stress

-Panting
- Lowered milk yield
- Shade seeking
- Grouping behaviour
-Increased aggresion
- Breathing heavy



How to prevent heat stress

-Provide adequate shading areas (trees or artificially made areas)
-Supplement cows with low levels of yeast
-Replace 25% of forage fibers (wheat) with non forage fibers (Soy)
-Choose darker cows

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