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Dairy Cow Welfare, Heat Stress and Climate Change

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Abstract

There has been widespread concern in the media regarding the impact that livestock have on global warming, particularly with methane from ruminants noted as a potent greenhouse gas. Less public debate has occurred however, on the potentially negative impact that global warming will have, indeed is having, on livestock welfare. Here we will first briefly discuss the effect of livestock husbandry on climate change before moving to a more detailed discussion of the effect that a warmer climate is likely to have, again is currently having, on the physiology and welfare of cattle across the world. Finally, we will briefly discuss measures that can be taken to reduce the impact of temperature increase on dairy cattle.

Introduction

Recent research has estimated that while cattle provide just 18% of the world's dietary calories and 37% of protein, they use a huge proportion (83%) of agricultural land and produce 60% of agricultural greenhouse gas emissions [1]. Understandably, given these figures, most public concern regarding cattle and climate change has focussed on the animals as an important causative agent with broadcast media highlighting the problem [2]. Public understanding of the impact of global warming on cattle welfare is significantly less, although some newspapers have noted the problem [3]. The effects of heat stress on beef and dairy cattle have been recognised by the farming industry for some time but the link with increasing ambient temperature is only recently being highlighted. Here we look at the effects of heat stress on cattle and the impact that global warming will have, indeed is already having, on cattle welfare.

Heat Stress and the Lactating Cow

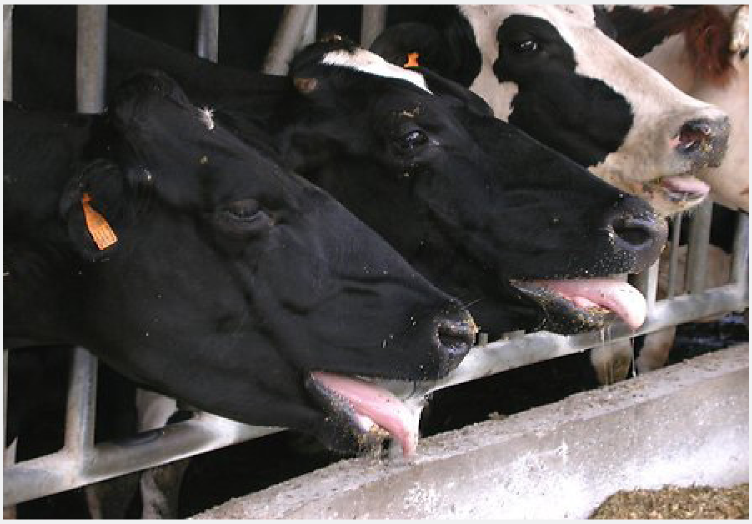

Figure 1: Dairy cattle showing clear respiratory signs of heat stress (Solvay).

The lactating dairy cow already has an increased internal temperature through her milk production (Figure 1). Heat production through metabolic functions is estimated to account for around a third of the energy intake of a 600kg cow producing 40kg of milk daily with a far level of 4% [4]. A study comparing cows that were non-lactating, or at low (18.5kg/d) or high (31.6 kg/d) milk yield showed that low and high yielding cows generated 27 and 48% more heat than nonlactating cows even though they had a lower body weight [5]. Whilst in cold environments dissipation of such body heat is not a problem, during periods of elevated ambient temperature, heat loss can be a significant problem for dairy cattle. The limiting factor for cattle at peak lactation is energy intake and a common management practice is to increase energy density of the diet by decreasing forage and giving a mixed ration with a high energy density. A side effect of feeding such a high energy ration is that of increased heat production; Reynolds and colleagues showed that heat production for heifers ingesting 4 and 7kg dry matter per day was around 40 and 56MJ/d respectively [6].

The irony, if we are aiming to increase dietary intake in cattle living on the metabolic knife edge of maximum productivity, is that heat stress leads to reduced feed intake, decreased activity and increase in peripheral blood flow to aid perspiration [7] while decreasing portal blood flow taking nutrients from the intestines to the liver [8]. Lough's 1990 paper also showed a reduced vascular supply to the mammary gland in times of heat stress, reducing milk production. Other effects of heat stress on lactation include a decline in plasma somatotrophin and triiodothyronine and thyroxine [9]. Heat stress alters blood acid-base balance, since panting animals lose carbon dioxide and thus have a respiratory alkalosis [10]. Compensation for this involves increased renal excretion of bicarbonate in times of heat stress, leading to a paradoxical metabolic acidosis during the cooler hours of night-time. This in turn leads to a loss of bicarbonate buffering capacity which can be critical if cattle are being fed high grain rations. To add to the cow's electrolyte compromise, potassium loss through increased sweating can lead to hypokalaemia [11].

What impact do these metabolic changes in heat stress have on the affective status of the animal? As far back as 1968 Collins and Weiner suggested that acute heat stress had emotional effects on dairy cattle [12] and subsequent work confirmed that heat-stressed cattle have higher cortisol levels than animals kept in cooler environments [13]. Animals with a reduce dry matter intake during heat stress are not only physiological stressed, losing body weight, but also emotionally affected by hunger [14]. We know that cattle given a limited grazing period have higher plasma levels of ghrelin, the 'hunger hormone' [15] and it is reasonable to assume that cattle reducing their dietary intake through heat stress will experience the same endocrinologic and affective state. Thirst too is a classic response to heat stress and providing adequate water is essential [16] with chilled drinking water alleviating both thermal issues and thirst [17,18]. Stermer's research [17] was undertaken more than thirty years ago and yet it must be asked how many farms are providing chilled water for their dairy cattle in times of heat stress. Such information is difficult to access, but this author's impression is that few are.

What influence does heat stress have on lameness and pain in dairy cattle? Heat-stressed cattle increase their standing time to allow greater body surface area to be exposed to the air for heat loss by convection. Lying time is reduced by 30% with higher ambient temperatures [19] and increased periods of standing have been suggested as a significant risk factor for lameness which is already a substantial cause of pain in a sizeable proportion of dairy cattle [20]. It has been suggested that the conflict between whether to stand up and increase cooling or to lie and relieve pain form lameness might be a significant factor in frustration in dairy cattle, a potentially important affective influence on their welfare [21]. Leg stomping, weight repositioning and butting, potential behavioural indicators of frustration, have been noted in cattle deprived of the opportunity to lie [22] and it would be a valuable exercise to assess the prevalence of such behaviours in heat stressed cattle as compared with the same animals in cooler environments.

Heat stress also reduces fertility in cattle. While results of research on the effect of heat stress on reproductive endocrine status have been varied, plasma luteinising hormone pulses have been shown to be of lower amplitude and frequency in periods of high ambient temperature [23] and plasma oestradiol concentrations are lowered by heat stress in dairy cows. Plasma progesterone levels are influenced by food intake and hepatic metabolism as well as luteal function, so the influence of heat stress on progesterone production is complex, but effects of heat stress on this hormone will affect the survival of an implanting fetus in the uterine wall as well as oocyte formation with deleterious effects on oocyte maturation and embryonic death.

Opportunities to Alleviate These Issues

Ambient temperature increases are to be expected in the future, so one must ask what measures can be put in place to manage heat stress in cattle. A personal experience might be worth noting here. On a visit to the Department of Veterinary Medicine in the University of Khartoum, Sudan I was at first horrified to see Holstein Friesian cattle, imported from Holland, kept in the elevated temperatures of this African country. Inspection of the farms however showed the use of large water misting fans to cool the cattle (Figure 2). This together with adequate provision of shade allowed the cattle to live comfortably. Indeed, the human inhabitants of Khartoum have borrowed that technology and now use water-cooling fans in up-market restaurants in the city! It is not only equatorial Africa which is using such technology in the livestock industry. American and Australian dairy farms are now also using fan assisted cooling and sprinklers more and more [24]. With an estimated reduction in lactation of up to 35% in mid-lactating heat-stressed cows it has been suggested that the US dairy industry is losing between $900 and $1500 million annually [25]. Clearly reducing heat stress is not only a welfare issue, but also a commercial imperative.

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Figure 2: Misting fans can significantly reduce heat stress (Masterkool).

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