Topic Summary

Dairy farmers rely heavily on the reproductive success of their cows so to improve and control productivity, cows do not mate, they are instead artificially inseminated (Sammad et al., 2020). When using artificial insemination, farmers try to estimate the time of estrous to be more efficient, but heat stress can greatly affect expression of the behaviour causing farmers to miss ovulation (Akbar et al., 2021; Her et al., 1988; Penev et al., 2021; Pennington et al., 1985; Rodtian et al., 1996; Schüller et al., 2017). This review focuses on estrous behaviour in female dairy cows with an emphasis on the effects of heat stress and the resulting influence on reproductive success. Estrous behaviour in cows is often described as a set of actions that include females mounting or being mounted, chin touching, licking, and sniffing the rumps of other cows (Hein & Allrich, 1992; Rodtian et al., 1996).

Much of the research on this topic focuses on hormones and how heat stress can alter various hormone levels and endocrine pathways. Hein & Allrich (1992) found that when adrenocorticotropic hormone, a stress hormone, was injected into cows in large enough doses it was able to delay estrus behaviour. Roman-Ponce et al. (1981) looked at shade management systems and how they effected hormones levels and estrous behaviour. They analyzed blood samples and found that when cows didn't have access to shade they had higher levels of stress hormones, altered steroid concentrations, and reduced feeding behaviour (Roman-Ponce et al., 1981). Reduced feeding behaviour (Roman-Ponce et al. 1981) can cause a negative energy balance (when more energy is lost than gained) which may cause a reduction in estrous behaviour or other behaviours (Sammad et al., 2020). Taken together, these studies suggest that estrous behaviour is largely influenced by stress, and it has been hypothesized that an extreme stressor can inhibit estrous temporarily (Hein & Allrich, 1992).

Stress hormones alone do not regulate the estrous cycle so additional research was needed to fill in the gaps. With a focus on estrogen and the amount needed to induce estrous behaviour, Alba & Asdell (1945) found that low doses could induce early stages of estrous behaviour but high doses produced no changes in estrous patterns. Hormones both control and are controlled by follicles developing in the ovary (Schüller et al., 2017). Schüller et al. (2017) used blood samples and imaging technology to observe that for every day a cow is exposed to heat stress during early estrous there is a continued decrease in follicle size, progesterone, and estrous behaviour (Schüller et al., 2017). Taken together these studies highlight that estrogen plays an important role in regulating estrus expression (Alba & Asdell, 1945) and heat stress not only affects estrous behaviour but also quality of developing follicles.

Some experiments focused primarily on changes in behaviour patterns rather than hormone analysis to reach their conclusions (Akbar et al., 2021; Her et al., 1988; Pennington et al., 1985; Rodtian et al., 1996). These studies observed cows with various methods such as continuous observation or by using AI monitoring systems (Akbar et al., 2021; Her et al., 1988; Pennington et al., 1985; Rodtian et al., 1996). They discovered that cows experiencing heat stress had reduced mounting activity, increased chin touching, licking and sniffing, and they were more likely to exhibit estrous behaviour during the night or in places with good footing (Akbar et al.,

2021; Her et al., 1988; Pennington et al., 1985; Rodtian et al., 1996). These observations may help to explain why approximately 50% of estrous events are missed by farmers (Pennington et al., 1985).

This area of research has been well studied and there is not much that remains unknown. However, as climate change spreads across the world, researchers understand that they need to stay ahead of this issue (Penev et al., 2021). Future research could include finding phenotypes that increase heat tolerance in cows such as hair colour and density (Penev et al., 2021; Sammad et al., 2020). Another future topic of research could include investigating a possible connection between an increased rate of twinning events in heat stressed cows (Sammad et al., 2020) and the birth of infertile freemartin cows, an event seen in twins (Alba & Asdell, 1945).

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