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Social stressors and their effects on immunity and health of periparturient dairy cows[1]

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ABSTRACT

Management practices during the periparturient period have been the focus of much research recently because during this period immune function, metabolism, and health of cows are severely challenged. Responses to stress are often classified as behavioral, immunological, neuroendocrine, and autonomic. In production systems, understanding all facets of stress response is important to correctly predict the consequences of stressors to the health and performance of animals and to prevent costly managerial changes that have minimal effect on animal well-being and performance. Common social stressors faced by periparturient animals are regrouping, overstocking, and for nulliparous animals, commingling with parous animals. In conventional dairies, feeding strategies during the periparturient period often require several group changes during the most challenging period of an animal's life. Traditional weekly regrouping of prepartum cows increases competitive behavior at the feed bunk but it does not affect immune and metabolic responses, health and production, as long as stocking density is not overwhelming, and nulliparous and parous animals are housed separately. Stocking density of prepartum animals may be overlooked because these are nonproductive animals. Severe overstocking (200% of feeding space) of commingled nulliparous and parous pregnant animals produces neuroendocrine and metabolic changes. On the other hand, when prepartum nulliparous and parous animals are housed separately, stocking densities of up to 120% do not seem to affect innate and adaptive immunity, metabolic responses, milk yield, and reproductive performance, despite increasing negative behavior among cows. In recent experiments, when animals were ranked based on feed bunk displacement, dominant animals were more likely to be diagnosed with metritis than subordinate animals. Importantly, dominant animals with large number of interactions with pen mates (displacement at the feed bunk) were considerably more likely to be diagnosed with uterine diseases (retained placenta and metritis) and to be removed from the herd within 60 d postpartum. Much has been learned about behavioral responses of cows to stressful conditions, but our understanding of neuroendocrine and immune responses to such conditions is somewhat limited. A multidisciplinary approach to research that encompasses several responses to stress and biological functions is critical.

Key words: periparturient cow, social stressor, immune function, health

INTRODUCTION

Stress has many definitions, etiologies, and consequences that are not necessarily identical to all animals or to all stressors. Once a stressor is identified, the body organizes a biological response that, according to the stressor, may be autonomic, neuroendocrine, immune, or behavioral or a combination of them (Moberg, 2000). Often biological responses to stress are sufficient to eliminate the stressor without significant alterations to the biological functions of the animal. Severe or chronic stress, however, may be of sufficient magnitude to produce biological responses that alter biological functions, disrupt homeostasis, predispose the animal to pathological conditions, and cause pathologies (Moberg, 2000). Autonomic response (fight or flight response) is short lived, involves the cardiovascular and gastrointestinal systems and the adrenal and exocrine glands, and has minimal effect on the biological function of animals that survive the stressor (Elsasser et al., 2000). Neuroendocrine responses, which involve the hypothalamus-pituitary-adrenal axis, may result in

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significant changes to the secretion of glucocorticoid, prolactin, somatotropin, thyroid stimulating hormone, LH, and FSH and are believed to have a profound effect on immune and metabolic functions (Elsasser et al., 2000). Innate and adaptive immune responses to a stressor are mounted depending on the etiology and immunogenicity of the pathogen (Elsasser et al., 2000). Nonpathogenic stressors, however, may have a direct (i.e., malnutrition, heat stress) or indirect (i.e., through glucocorticoids and somatotropin) effect on immune function (Elsasser et al., 2000). Finally, the behavioral response is mounted once a perceived threat to homeostasis is identified (Elsasser et al., 2000). For example, an animal exposed to heat stress seeks shade and water to reduce body temperature (Kendall et al., 2006), whereas a submissive animal avoids the feed bunk while more dominant animals are feeding (Friend and Polan, 1974).

Although one may argue that stress and biological responses to stress have little relevance if no consequences to biological functions of the animals are observed, this mindset is not acceptable to some consumers in most developed countries or by the scientific community because of ethical considerations. On the other hand, many experiments have focused on one biological response to stress (i.e., behavior) but were not necessarily designed to evaluate other biological responses to stress and their consequences to the biological function of the animals. As we increasingly attempt to improve well-being of animals through proper managerial strategies, while maintaining sustainability of food-producing industries, a holistic approach must be taken and evaluation of biological responses to stress, biological function, incidence of pathological conditions, and mortality must occur. Affective state is another area of importance to the evaluation of animal well-being. Although it is often counterintuitive to consider that animal feelings can be evaluated, researchers have been working on developing reliable measures of affective state (e.g., pain, fear, pleasure, preference). In general, such evaluations are based on what are believed to be responses associated with the affective state that the animal is in. Perception of pain, for example, may be evaluate by a wide range of techniques such as thermal, electrical, and mechanical stimuli (Melia et al., 2015). Pressure algometry appears to be a more objective method for evaluation of pain (Melia et al., 2015) and has been used to measure efficacy of therapeutic interventions for pain prevention and treatment (Stock et al., 2015). In experimental herds, it is possible to conduct experiments to determine the preference of cows to different management conditions (e.g., access to pasture; Legrand et al., 2009) and facilities (e.g., freestall design; Abade et al., 2015).It has been suggested that natural behaviors of dairy cows such as resting, feeding, and rumination are associated with health, welfare, and productivity (Grant, 2007). Situations of limited space, limited feed, elevated stocking density, and frequent regrouping (physically moving cows from pen to pen) may increase the competition for resources, limit cows' ability to behave naturally, and increase expression of aggressive behaviors (Friend and Polan, 1974; Wechsler, 2007). Although the focus of this review is not the consequences of social stressors on behavior, behavioral responses may directly or indirectly affect immune status, and the animal's response to social stressors is often behavioral in nature (e.g., altered feeding behavior of a subordinate cow).

The effects of limited access to resources and social stressors on immune function, metabolic status, health, and performance of dairy cattle are less understood. However, if situations of social stress result in changes in feeding behavior and reduced DMI, such stressors may exacerbate negative energy balance during the periparturient period and predispose dairy cows to immunosuppression, metabolic disorders, and diseases. Therefore, a comprehensive review of the consequences of social stressors to immune function and health must also take into consideration behavioral responses and their consequences.

Stocking Density in the Periparturient Period

To increase herd size without increasing investments in facilities, many dairy farms chose to overstock (Bewley et al., 2001), particularly during the prepartum period. Grant and Albright (2001) suggested that housing a greater number of cows than the number of stalls available or decreasing the linear feeding space to <60 cm per cow characterizes overstocking. On the other hand, the Canadian Code of Practice for Dairy Cattle (DFC-NFACC, 2009) suggests that decreasing the linear feeding space to <76 cm per prepartum cow characterizes overstocking (DFC-NFACC, 2009). Many believe that overstocking can be overcome by dairy animals when feed is available 24 h per day because there would be constant rotation of animals eating, drinking, and resting. Dairy animals, however, present allelomimetic behavior and typically 80% of headlocks are occupied at peak feeding time, after fresh feed delivery, and animals that do not have access to fresh feed do not return to the feed bunk when their pen mates are not feeding (Nordlund et al., 2006). Huzzey et al. (2006) demonstrated that, following fresh feed delivery, approximately 80% of cows were at the headlock when they were housed in pens with 1.33 and 1 headlock/