Consequences of stress for immune function in dairy cows

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Abstract

In the nineties, yearly average milk production levels by dairy cows in Western countries, such as The Netherlands, increased from around 5,000 to around 7500 kg milk with extremes of 15,000 kg and more. The selection for a higher yield increases feed intake, but simultaneously increases the energy gap between yield and intake, i.e. the level of metabolic stress. A number of so called production diseases seem to originate from the peripartum period when cows experience stress due to parturition, changes in their environment and poor energy balance. Innate and acquired defence mechanisms seem to be weakest from week 3 prepartum to week 3 postpartum and cows that show hyporesponsiveness to ovalbumin or Escherichia coli J5 have increased incidences of peripartum diseases, particularly mastitis (Mallard et al. 1997, 1998). Possible underlying factors include stress related endocrine changes (Kimura et al. 1999). The foregoing leads to concerns about the effects of increasingly higher milk yields on the health and welfare of dairy cows. The hypothalamic-pituitary-adrenal cortex (HPA) axis is pivotal in stress responses and may play a key role in the cows’ ability to deal with high milk yields and energy deficits. The Institute for Animal Science and Health (Division of Animal Sciences) and The Faculty of Veterinary Medicine (Department of Farm Animal Health, Ruminant Health Unit), investigated possible relationships between milk production level, HPA function and immune competence.

In stressed cattle, as in other mammals, the central nervous system evokes physiological responses that ultimately result in activation of the sympatho-adrenal axis and the hypothalamo-pituitary-adrenocortical (HPA) axis. The responses of these major systems have adaptive value and the ability to achieve stability through changes, i.e. allostasis, is critical to survival (McEwen 1998). Through allostasis the autonomic nervous system, the HPA axis and the cardiovascular, metabolic and immune systems protect the body against internal and external stress. However, prolonged overactivity or underactivity of an allostatic system such as the HPA axis may lead to allostatic load, e.g. wear and tear, and damage the immune system. Stress is associated with corticotropin releasing hormone (CRH) releases from the hypothalamus. CRH causes adrenocorticotropic hormone (ACTH) releases from the pituitary, which in turn stimulates the adrenal cortex to release glucocorticoids (in cattle cortisol supersedes corticosterone in concentrations). In part, effects of stress on immunity run via this HPA axis and in cattle the synthetic glucocorticoid dexamethasone induces neutrophilia, eosinopenia, lymphopenia, monocytopenia and leucocytosis. In vitro assays with cells from dexamethasone treated cattle show that the chemotaxis of peripheral blood neutrophils is increased, but that mononuclear cells show suppressed mitogen induced interferon-gamma production (e.g. Nonnecke et al 1997). In dairy cows, glucocorticoids repress the expression of neutrophil adhesion molecules, thereby preventing migration to underlying tissue, leading to neutrophilia and increased mastitis susceptibility (Tempelman et al. 2002). Stress hormones may suppress the production of Tumor Necrosis Factor-alpha by monocytes and this
could contribute to the higher susceptibility of cattle to Gram-negative bacterial infections of the udder during stress (Diez-Fraile et al. 2000). Investigating intact and mastectomized cows, Kimure et al (1999) found that the expression of L-selectin (for capture and rolling adhesion) was transiently suppressed at parturition. Neutrophil myeloperoxidase (bactericidal) activity decreased with approaching parturition, but recovered to prepartum values with a week only in mastectomized animals. The metabolic stress of lactation may exacerbate periparturient immunosuppression, but it is yet unclear if this is worse in the higher yielding animals. Preliminary findings by The Institute for Animal Science and Health and The Faculty of Veterinary Medicine suggest that dairy cows are HPA hyporesponsive in the first weeks postpartum without clear effects of milk production level. The absence of such effects on host resistance is consistent with the assumed key role of the HPA axis in dealing with (metabolic) stress.


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Systeemontwikkelaar (Hoge school Arnhem / Universiteit Nijmegen)

Employement
Promotie onderzoek naar stress en welzijn bij honden (02-1993 tot 01-1997, Universiteit Utrecht)

Rapportage mogelijke dierenwelzijnproblemen in de paardenhouderij (RDA).

Begeleiding promotieonderzoek naar ‘effect of milk production level on adaptive capacity’ (NWO/LNV)

Lopend (beginnend) onderzoek naar ‘diergezondheidsrisico’s van hoge producties bij melkvee, rekening houdend met genetische aanleg, management en interacties’ (LNV).

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Recent work