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HEALTHY HERD MANAGEMENT REPORT

Relationship Between Stress and Health in Cattle - Part 2

Jeffery A. Carroll, PhD and Nicole C. Burdick Sanchez, PhD
Livestock Issues Research Unit, USDA-ARS

Introduction

Numerous physiological and psychological conditions significantly influence the health and subsequent growth of livestock.

In domestic livestock, increased stress hormones in response to managerial stressors have been linked to reduced rates of reproduction, suboptimal growth, suppressed milk production, and suppression of immune function that could increase susceptibility to disease (Lay et al., 1992; Buckham Sporer et al., 2008).

Through an understanding of the interactions between the stress system and immune function, animal management practices can be modified to reduce negative impacts on growth and productivity in livestock.

The Immune System

To aid in understanding the relationship between "stress" and animal health, it's important to understand that the immune system is not a single entity, but rather a complex, integrated system regulated by a multitude of specialized cells and chemical messengers.

In general, however, the immune system can be separated into three broad components; *natural immunity, innate immunity, and acquired immunity,* all of which must be fully developed and functioning properly to provide adequate immunological protection.

Natural and innate immunity are typically grouped together under the category of innate immunity. Therefore, when discussing innate immunity, it is typically assumed that one is including natural immunity as well.

Innate immunity is considered to be the first line of defense against pathogens; whether bacterial, viral, protozoal or fungal. It includes physical barriers such as the skin, mucosal secretions, tears, urine, and stomach acid, as well as complement and antigen-nonspecific cellular components and is designed to elicit an immediate or acute response (0-to-4 hour) following exposure to an antigenic agent.

Until recently, the innate immune system was thought to represent the antigen-nonspecific aspect of the immune system. However, recent evidence suggests that the innate response may be specific to the pathogenic agent encountered.

While it is often assumed that this aspect of the immune system becomes a constant entity once developed by the animal, this is certainly not the case. The innate immune system, while always present to some degree, can be modulated in either a beneficial or detrimental manner by a number of factors including wounds, dehydration, nutritional status, genetics, stress, and various peptide hormones (Figure 1).

Stress and the Immune System

While it has been known for decades that "stress" can have detrimental effects on the immune system, it was only recently that the divergent effects of "acute" stress compared to long-term or "chronic" stress were revealed.

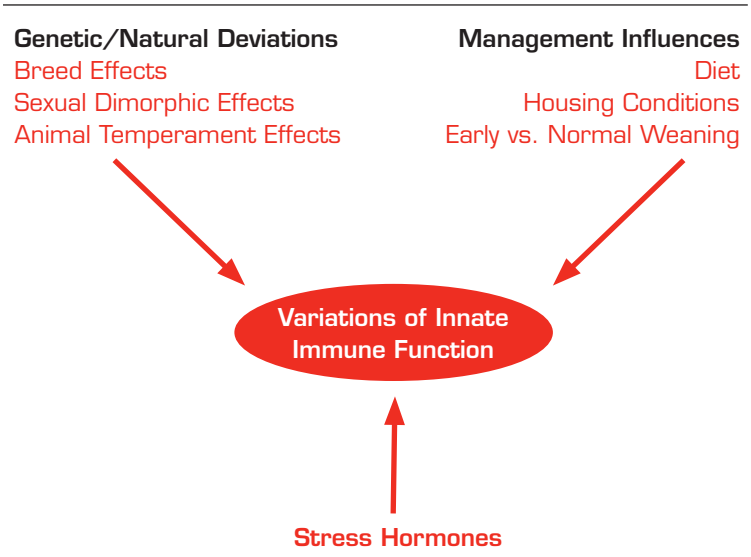

Figure 1: Factors that can have a significant influence on the function of the innate immune system of cattle. Naturally occurring deviations in the innate immune system, as well as the influence of various management practices on the immune system, are often overlooked in production systems (Carroll, J.A. and N.C. Burdick. 2011. Relationships between Stress and Health in Cattle. Prince Agri Products, Inc. Advisory Bulletin, June 2011).

As the scope of scientific exploration has expanded beyond traditionally defined pathways of neuroendocrinology, endocrinology, and immunology, multidisciplinary efforts emerged leading to the identification of cross-communication pathways among the stress and immune systems, and to a better understanding of homeostatic regulation within the animal.

No longer is stress considered strictly immuno-suppressive. Indeed, stress may elicit "bi-directional" effects on immune function such that acute stress may be immuno-enhancing, while chronic stress may be immuno-suppressive.

Today, our knowledge base has expanded, and a greater appreciation and understanding has emerged regarding the plethora of immune system activities that are influenced by cortisol such as stimulation of immune system chemical messengers, and stimulation of immune cell growth and function (Figure 2).

Rectal Temperature and Cortisol Response to an LPS Challenge

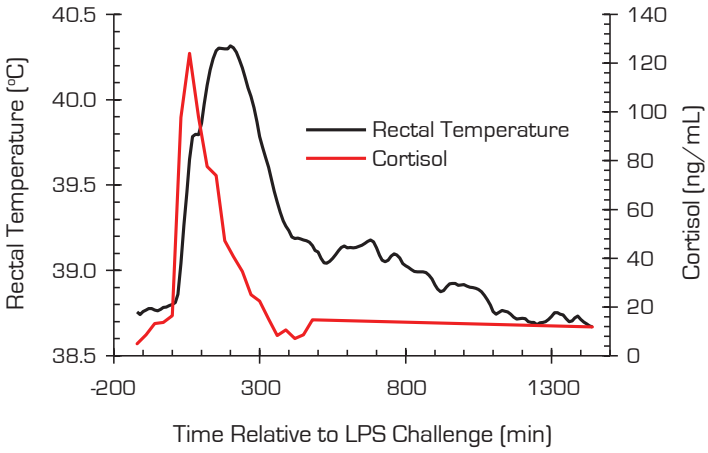

Figure 2. The body's response to an antigen includes increases in stress hormones and body temperature. Cortisol and catecholamines, as well as cytokines released from immune cells, stimulate an increase in body temperature in an effort to kill invading pathogens. The above figure depicts increases in rectal temperature and serum cortisol in cattle following exposure to lipopolysaccharide (LPS). (Burdick et al., 2011.)

In addition to these stimulatory actions, long-term exposure to cortisol is known to inhibit aspects of immune function. Ultimately, within the animal, the immune system response to stress is dependent upon the type of stress encountered (i.e., acute versus chronic).

In some instances of acute stress, such as that resulting from bites, punctures, scrapes or other challenges to the integrity of the body, stress hormones are associated with priming the immune system in a manner to prepare for potentially invading pathogens and subsequent infection.

However, when an animal experiences prolonged or "chronic" stress, the effect of stress hormones on the immune system shifts from a preparatory event to a series of suppressive events; first at the cellular level and then eventually across the entire immune system spectrum.

While the discussion pertaining to the influences of stress on the immune system have been primarily focused on the actions of cortisol, one cannot discount the involvement of the catecholamines, epinephrine and norepinephrine, as modulators of the immune system.

An increase in circulating concentrations of catecholamines following a stressful event has been previously reported to modulate immune cell activities such as proliferation, cytokine and antibody production, cytolytic activity, and cell migration.

As with cortisol, the effects of epinephrine and norepinephrine on the immune system can be both stimulatory and inhibitory. Prior research has demonstrated potential immuno-enhancing roles for both of these stress hormones.

Conclusion

Ultimately, the combined immunological effects of cortisol and catecholamines result in a well – orchestrated event designed to prevent over-stimulation of innate immunity while simultaneously priming the acquired immune response.

Therefore, the final type of immune response that prevails within an animal is dependent upon the overall type and duration of the stress response in the animal.

Given that the innate immune system provides the first line of defense, understanding the effects of stress hormones on innate immunity holds a great deal of potential with regard to improving cattle health, and ultimately productivity (Figure 3).

Steer Body Weight Relative to an LPS Challenge

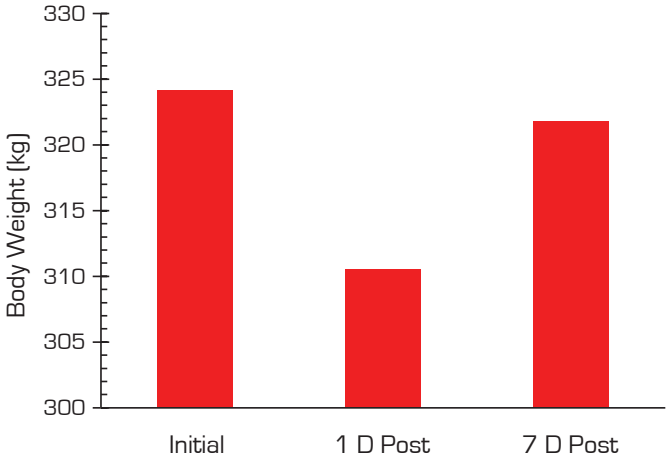

Figure 3. In response to an immune challenge, body resources are redirected away from growth towards the immune system, resulting in a decrease in body weight. When challenged with lipopolysaccharide (LPS), a component of the cell wall of gram-negative bacteria (e.g., *Escherichia coli*), steers exhibited a 4.2% decrease in body weight within 24 hours (1 D Post). (Bernhard et al., 2012)

Continued research efforts into these complex interactions may allow the implementation of alternative management practices, improved selection programs, and/or implementation of various nutritional strategies to prevent or overcome significant production losses and animal health care costs for livestock producers.

References

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