J. Dairy Sci. 99:1–18
http://dx.doi.org/10.3168/jds.2015-10198

Stress, immunity, and the management of calves[1]

Lindsey E. Hulbert[2] and Sonia J. Moisá
Department of Animal Sciences and Industry, Kansas State University, Manhattan 66506

ABSTRACT

Despite many advances in management and housing of dairy calves, 1 in 10 US dairy heifers die before weaning. A better understanding of the internal and external stimuli that contribute to the physiological and behavioral responses of calves to stressors is needed to reduce the risk of morbidity and mortality. Feeding calves their first meal is crucial, as successful passive transfer reduces the risk of mortality and morbidity. Sexually dimorphic immune and stress responses appear to be present in young cattle, but more research is needed to determine if this is caused by human bias for female calves. After that first feeding, 1 in 10 heifers and most bull calves in the United States are transported to specialized calf-raising facilities, yet information is lacking on the newborn calf stress response during transit. Whether calves are raised on site or at a calf ranch, individual housing systems are commonly used in the United States to reduce the risk of pathogen exposure and provide individual feeding and healthcare. However, health, growth, and social implications may be present for calves in alternative systems with greater space allowance than conventional systems or group housing. Disbudding and castration are typically performed at an early age for dairy calves during the pre-wean stage. These stressors often take place when the calf has decreased passive transfer of Ig and immunity is developing. Availability of pain mitigation through anesthetics and analgesics is limited, but evidence indicates that analgesics attenuate suppressed leukocyte function during these procedures. Solid-feed intake is a primary measure for determining weaning readiness, but some milk replacer formulas may influence the calf's oral behaviors before weaning; therefore, alternate weaning methods may need to coincide with alternate milk replacer formulas. The calf's behavioral and stress response at weaning may influence its immunity during the transition from individual to group housing (commingling). Alternate commingling strategies and nutritional supplements may help with this transition, but more research is needed to explore feasible alternatives. Optimizing the calf's health and well-being at these early stages may improve its long-term health and welfare.

Key words: early life, immunity, stress, neonate

INTRODUCTION

Welfare of dairy calves can be improved through management strategies that help improve resilience to stress and disease. Scholars and producers often debate if performance is a measure of animal welfare (Moberg and Mench, 2000; Rollin, 2003; Fraser, 2008; Appleby et al., 2011). Among mature animals, performance is defined and measured, and some clear implications for animal welfare were found (Grandin, 2015). For example, age at calving, milk production, quantity and quality of semen, and quality and quantity of meat at slaughter are performance measures for dairy heifers, cows, bulls, and steers. For these mature animals, the links between performance and animal welfare are established and understood. A cow may not let down milk if she is mishandled (Seabrook, 1980; Rushen et al., 1999). A heifer may have low conception rates if she has low or high BCS (Davis Rincker et al., 2011). A bull may produce less quantity and quality of semen if he is chronically sick (Smith Thomas, 2014), and a steer may produce lactate that ruins meat quality if he is mishandled during slaughter (Gruber et al., 2010). But, what is performance for the dairy calf and are there clear connections to their short-term and long-term welfare?

Performance measures may not always be appropriate well-being indicators during certain critical windows for dairy calves. For example, a benchmark of calves to double their birth weight by weaning was cited as a best standard practice for calf raisers (James, 2008; AJCA, 2015). However, the majority of US dairy calves wean at an average of 8.2 wk of age (Figure 1), which is 6 to 10 mo earlier than if dams weaned calves naturally

Received August 2, 2015.
Accepted December 4, 2015.
[1]This review paper is from the proceedings of the Animal Health Symposium: Understanding and Reducing the Impact of Various Stressors on Immune Responses and Health of Cattle at the ADSA-ASAS Joint Annual Meeting, Orlando, Florida, July 2015.
[2]Corresponding author: lhulbert@ksu.edu

(Jones and Heinrichs, 2007). If one considers the many management and critical windows in the pre-weaned calf's timeline (Figure 1), it is not surprising that the majority of US heifers do not double their birth weight until at least 2 wk after the average weaning age (Figure 1; NAHMS, 2007). Furthermore, most calves have little weight gain after the first week of life (Figure 1; NAHMS, 2007). This is not uncommon for many neonates; in pediatric medicine, healthy human infants are expected to lose some weight after birth; then they should at least reach their birth weight at their 2-wk checkup (Tawia and McGuire, 2014).

Milk and milk replacer are valuable commodities. Therefore, it is more economical in the short term to optimize the amount and time that milk products are fed to dairy calves (Davis and Drackley, 1998). Weaning dairy calves from liquid milk or milk replacer is likely a different type and severity of stressor than weaning beef calves from their dams (Hulbert et al., 2011a,c). Some researchers suggested increasing milk replacer nutritional content to attain high pre-wean ADG (high plane of nutrition, **HPN**; Raeth-Knight et al., 2009; Davis Rincker et al., 2011; Soberon et al., 2012). However, many research experiments have not replicated such a benchmark through accelerated milk nutrition alone (Jones and Heinrichs, 2007; Hill et al., 2010, 2011b, 2013). Regardless if HPN calves reach this benchmark before weaning, the weaning timeline may

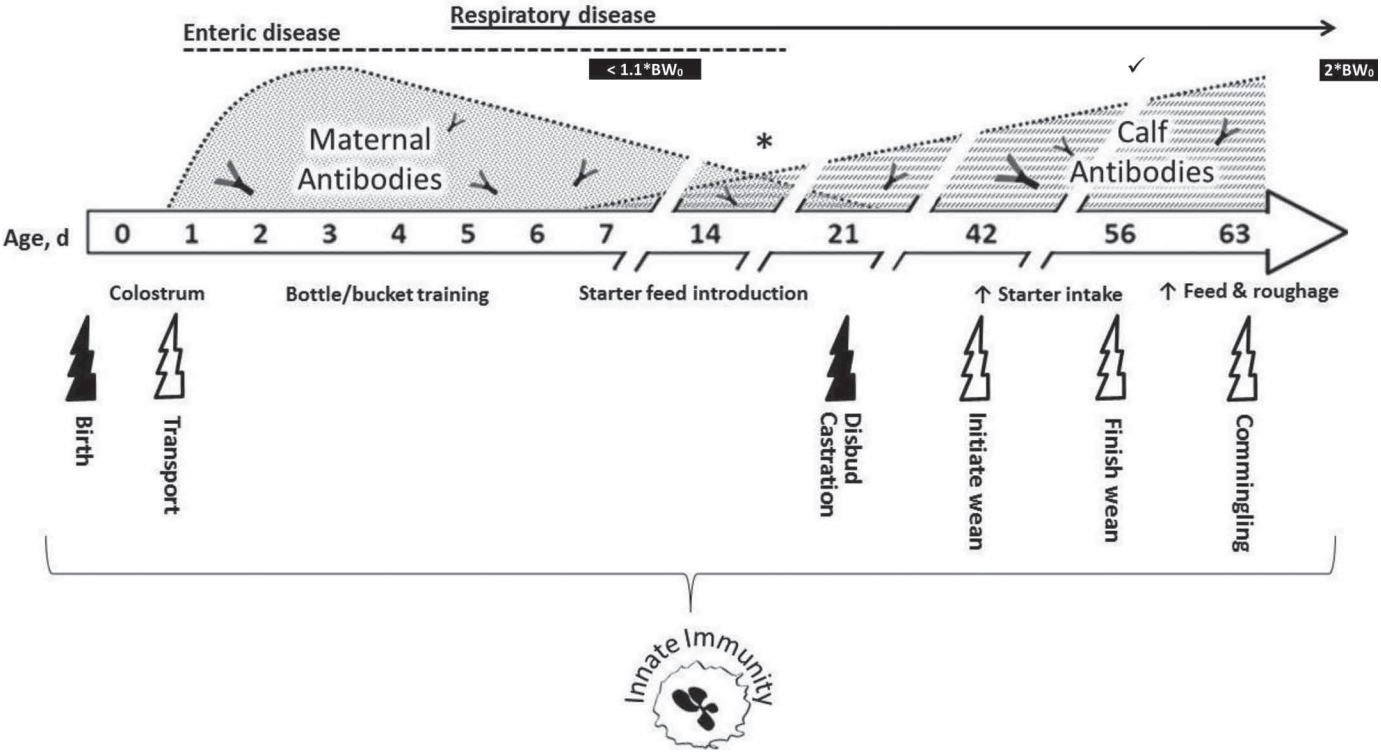

Figure 1. Dairy calf stress, immunity, and management timeline. Potential inflammatory (black-bolt) and psychological (white-bolt) stressors are inevitable for the developing, hand-fed dairy calf. Birth is the first direct stressor in a calf's life, although the prenatal environment can influence the fetal stress-axis. Calves must be provided colostrum to gain passive transfer of maternal antibodies (Y). Calves that experience difficult births are more likely to have failure of passive transfer (FPT); bull-calves also have a higher rate of FPT than heifers, regardless of birthing difficulty. Transportation is a known stressor to mature animals. One out of 10 heifers and most bull calves are transported to a calf-raising facility within a day after birth. The stress of birth and transportation may influence bottle training of calves; over one-half of US dairy heifers were fed medicated milk replacer. High quality feed (starter) was introduced to healthy calves at an average of 1 wk of age and water at an average of 2 wk of age. Roughage is not introduced until enteric disease risk decreases, which is after 3 wk of age. One out of 3 heifers experience enteric disease (dashed-line) in the preweaning stage; therefore, 7 out of 10 calves are penned individually to avoid disease transmission. Typically, producers choose to castrate male calves and disbud between 3 and 4 wk of age, which is an inflammatory stressor. This is the same period (*) when antibodies from passive transfer are low, and the calf is just beginning to have its own antibody responses to environmental microbiota. The average age calves are weaned from milk or milk replacer is 8.2 wk, but weaning is often initiated 1 to 2 wk before by withdrawing a significant portion of the liquid diet, thus stimulating calves to consume more starter. Calves typically are not fully weaned until the last portion of liquid diet is removed. After weaning, calves that were individually housed will be moved into groups (commingling), which may be another potential psychological stressor that can exacerbate respiratory disease, which is the most common cause of morbidity and mortality in postweaned calves. A benchmark (checkmark) was proposed for calves to double birth weight by weaning, but on average, US heifers double birth weight about 2 wk after weaning ($2*BW_0$). Preweaning weight gain is marginal ($<1.1*BW_0$) in the first week or 2 of life.