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A REVIEW OF THE ADAPTATION OF THE NEWBORN CALF TO ITS ENVIRONMENT

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Abstract

During the first months of life, the calf needs to adapt physiologically to three challenges: extra-uterine life, maintaining the prolonged pre-ruminant stage and weaning. This paper aims to detail the newborn calf's adaptation to extra-uterine life, namely changes occurring at the digestive level, and less at the endocrine or immunological levels, knowing that the calf is born hypo- or a-gammaglobulemic. At birth, the digestive system of the calf is structurally complete (rumen, reticulum, omasum and abomasum), but functionally incomplete, as the abomasum is the only active compartment in the digestion of the pre-ruminant calf. From this moment and up to two weeks of life, the calf can be considered monogastric, as a result of the existence of an anatomical structure that ensures the passage of the colostrum/milk replacer to the abomasum.

The transition from intrauterine life to extra-uterine life is very demanding for the calf, as immediately after birth it has to adapt to new environmental and nutritional conditions. At birth, the young ruminant becomes dependent to the extra-uterine environment regarding food intake. Concerning the environment, the greatest adaptation efforts are related to thermoregulation, as the calf transitions from 38.8°C in utero to below 20°C in the shelter. After birth, changes in the newborn's energy metabolism determine the production of endogenous glucose and the use of fats to compensate for the continued loss of glucose. In the meat industry, young calves are generally fed by their mother and are weaned progressively. Instead, calves coming from dairy cows are separated from their mother immediately after birth and receive colostrum during the first two days of life and then milk or milk replacer for the next weeks. Ingestion of colostrum is essential for the morphological and functional development of calves. Maintaining the calves in a prolonged pre-ruminant phase (up to 3-5 months or more) is done in some European countries producing approximately 750 000 tons of veal, consumed annually in the European Union. Some dairy calves are maintained in a precursor stage for about a month and then weaned over a two-week period. At present, artificial colostration, due to the establishment of colostrum banks, is gaining more and more ground, thus giving up the direct contact of the calf with the mother.

Key words*: newborn calves, colostrum, thermoregulation, extra-uterine life.*

INTRODUCTION

Response mechanisms to environmental challenges of the newborn calves' population has been going on for thousands of years. Adaptation must be successful and populations must be capable of sustained production, but there are a few reasons for which adaptation might be difficult. Management systems are changing more rapidly, typically in the direction of greater intensification. Compared to only a few decades ago, for example, cows now produce their first calf at two rather than three years of age, animals are maintained at higher density per unit of land area and cattle are fed on higher energy diets (Hohenboken et al., 2004). In many instances, management systems and environments are changing more rapidly than animal populations can adapt through natural selection. Stress is a fact of life. Fortunately, response mechanisms have evolved to stressors commonly encountered in a population's evolutionary past. These physiological, immunological, metabolic and behavioral responses generally are sufficient to maintain biological integrity and physical well being. However, when responses are inappropriate or inadequate, stress can lead to distress, defined here as ill health or compromised well being (Moberg, 1999). In a maladapted population, inherent response mechanisms to prevailing environmental challenges do not maintain the well being of many individuals. An adapted population is one

in which most individuals cope successfully with those stressors most commonly encountered in their environment.

MATERIALS AND METHODS

We searched scientific databases for relevant articles identified by the keywords: newborn calves, colostrum, thermoregulation, extra-uterine life and we selected those articles which discuss the most important problems of the calves in their first days of life in regard to the productivity of the farmer. The different authors mention three critical points in the life of the neonate calf: the digestive system, heat stress and colostrum intake. Also, other problems like pneumonia, diarrhea, omphalitis, are mentioned in the sources consulted, from birth until weaning.

This research tries to evaluate the issues which healthy newborn calves face from birth up to 30 days of life, a period marked by organic adaptations to the environment and immunological immaturity.

RESULTS AND DISCUSSIONS

Newborn calves are very susceptible to lethal digestive, respiratory infections in the first days of life and also environmental stress might be a reason of newborn calve's pathology (Godfrey et al., 1991). Cattle management systems often dictate that calving occur at a time of the year when cold, fluctuating temperatures and increased precipitation are prevalent, usually in spring. Several researchers have observed that exposure to cold, wet weather has been involved in augmenting the problems observed in Weak Calf Syndrome (WCS) (Bull et al., 1978; Olson et al., 1980; Kvasnicka, 1982). During the fetal to neonatal transition, the newborn calf goes through severe thermolysis that is aggravated by the evaporation of fetal fluids and severe weather conditions. Maintaining homeothermy during the neonatal period requires a strong and sustained thermogenic response by the newborn calf. In regard to the environment, the greatest adaptation efforts are required for thermoregulation, as the calf transitions from 38.8°C in utero to below 20°C in the shelter (Kirovski, 2015). It is accepted that this thermogenic response is derived from both shivering thermogenesis in muscle tissue and nonshivering thermogenesis in brown adipose tissue (BAT) and it is critical that newborn calves possess functional BAT during the neonatal period (Carstens, 1994).

During the first few weeks of life, calves are functionally monogastric and milk is the primary source of nutrition. Upon drinking milk, the oesophageal (reticular) groove (sulcus reticuli) is activated and the milk is shunted past the forestomachs to the abomasum (Sjaastad et al., 2010). A number of factors trigger this oesophageal reflex: sucking behaviour, warm milk, the position of the calf's head while drinking and familiarity with the feeding method (Abe et al., 1979). For newborn and young calves, milk passage through the forestomachs is usually not problematic. The rumen, along with the reticulum and omasum, is not yet developed and empties into the abomasum within hours (Lateur-Rowet, 1983). The abomasum is able to gradually extend and accommodate different quantities of colostrum/milk (2-6.8 liters) without changes in the calves behaviour, without any indicative of abdominal pain (Ellingsen et al., 2015).

It is strongly recommended that calves be clinically examined immediately after birth in order to monitor cardio-respiratory function (heart rate, respiratory rate), evaluate the metabolic pathways (rectal temperature) and correct the irregularities (Uystepruyst et al., 2002).

Feeding also has a key role. It is essential that the newborn calves receive an adequate supply of colostrum as soon as possible, as both the concentration of immunoglobulins and permeability of the gut decrease rapidly over the first 24 hours following parturition (Weaver et al., 2000; Moore et al., 2005). Colostrum, the first milk neonates receive after birth, is rich in nutrient and non-nutrient biologically active factors. Colostrum feeding has an impact on postnatal development and possibly glucose homeostasis in several species (Koldovský, 1989, 1994; Kelly, 1994; Burrin et al., 1995; Savino et al., 2011).

The formation of colostrum in the cow's udder starts from the first day after calving. Its composition is similar to that of blood and differs significantly from milk (McGrath et al., 2015). Colostrum contains both nutrients

(proteins, fats, lactose, essential fatty acids and amino acids) and non-nutrients (biologically active substances). This is the first food the calves ingest after parturition that provides them with all necessary nutrients. Also, colostrum is particularly important for the passive immunization of the newborn, through the combination of various specific (immunoglobulins) and non-specific (humoral and cellular) antibacterial factors that pass to the offspring and protects them against infection during the first days after birth (Tomov, 1984; Medvezki, 1989; Iliev and Tomov, 1992; Blum and Hammon, 2000; Playford et al., 2000).

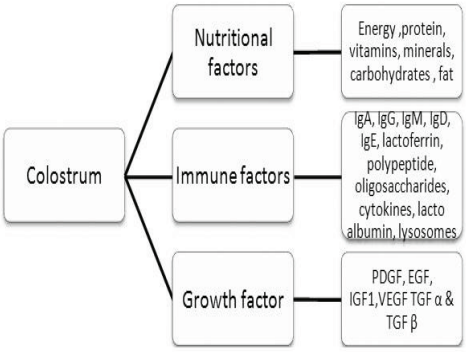

Figure 1. Composition of colostrum (Godhia, 2013)

Most nonnutritional components of colostrum are accumulated in the mammary gland during the prepartum period, so alimentation of the the mother in the dry-off period plays a key-role in the colostration period. Given the importance of physiological changes related to the critical period of adaptation of the newborn in the environment and high morbidity rate, collecting blood samples from calves could be a loial indicator of the health status of the animals (Silva et al., 2016; Windeyer et al., 2014).

A number of hormones are detected in colostrum and milk. Their concentrations in the first colostrum are many times higher than in milk (Table 1; Levieux, 1999).

The neonatal period of calves is characterized by an increase of disease susceptibility, especially diarrhea, umbilical cord inflame-mation and bronchopneumonia due to the immunological immaturity and a-gamma-globulinemic status of newborns at birth (Fontes Novo et al., 2015).

Table 1. Contents of some hormones in colostrum and milk (Levieux, 1999)

Hormone	Concentration
Insulin	colostrum: 4.2-34.4 ng/mL milk: 0.042-0.34 ng/mL
Total cortisol	colostrum: 4.4 ng/mL milk: 0.35 ng/mL
Free cortisol	colostrum: 1.8 ng/mL milk: 0.3 ng/mL
Prolactin	colostrum: 150 ng/mL milk: 50 ng/mL
Progesterone	colostrum: 2.6 ng/mL milk: 0.8 ng/mL

During this period, they are dependent on the maternal immunity transference by colostrum intake (Chase et al., 2008).

In newborn calves with diarrhea, the intestinal losses of bicarbonate and the formation of L-lactate by anaerobic glycolysis as a result of tissue hypoperfusion have been considered for a long time to be the main causes of metabolic acidosis. However, since Grude et al. (1999) first reported high serum concentrations of D-lactate in calves with neonatal diarrhoea that did not have abnormal ruminal contents, further evidence has been obtained that hyper-D-lactataemia frequently occurs in diarrhoeic calves (Omole et al., 2001; Lorenz, 2002). In human beings, substantial amounts of D-lactic acid are produced after the resection of large portions of the small intestines, when undigested carbohydrates are transported into the large intestine. The similarity of the clinical symptoms of the so-called short-bowel syndrome (ataxia, loss of memory, disorientation, headaches, slurred speech and alterations in consciousness up to coma) described by Uribarri et al. (1998) to the clinical signs observed in diarrheic calves with metabolic acidosis led to the assumption that these signs are influenced more by the concentration of D-lactate than by the degree of acidosis. In a study of calves with naturally acquired diarrhea, Lorenz (2004) has shown that changes in behaviour, and particularly in posture, can be better explained by an increase in serum D-lactate concentration than by the decreased base excess. The disturbance of the palpebral reflex is due almost completely to high levels of D-lactate (Lorenz, 2005). In that study all the calves had base excess values less than-10 mmol/litre and the study aimed to

investigate whether the clinical signs could be induced by hyper-D-lactataemia in the absence of acidosis. Previous studies consulted of the metabolism of D-lactate in ruminants have used adult animals (Stangassinger, 1977), and their additional objective was to investigate the ability of young calves to eliminate D-lactate from the blood (Lorenz et al., 2005).

Rupture of the umbilical cord that occurs during calving is characterized by hypoxia, responsible for the decreased blood oxygenation and increased blood concentrations of carbon dioxide, a substance that stimulates the gasping reflex, responsible for high lung compliance and establishment of final lung air volume. Increased oxygen tension in the blood and increased peripheral vascular resistance initiate closure of the *ductus arteriosus*, *foramen ovale* and *ductus venosus*, also preparing the neonatal cardio-vascular system for extra-uterine life (Nagy D.W., 2009). Umbilical cord inflammation is the most common affection in newborn calves, due to the environmental factors. Even if it is well treated with antibiotics, sometimes it could be also dangerous or fatal for the newborn calf (Kasari, 1994; Quigley and Drewry, 1998).

Respiratory disease in new born calves is a constant challenge for dairy replacement heifer rearing systems, and is responsible for 21.3% of mortality in pre-weaned calves and 50.4% of deaths in weaned heifers (Poulsen and McGuirk, 2009). Pneumonia known as shipping fever or Bovine Respiratory Disease (BRD), is the second most common cause of calf death. Calves that develop pneumonia before weaning are subjected to the same risk factors as those that become diarrheic: failure or incomplete passive transfer of immunity from colostrum, exposure to adult cattle, and/or the deficient ventilation in warm housing. The three most important infectious agents causing pneumonia in young calves are: *Pasteurella haemolytica, Pasteurella multocida* and *Mycoplasma dispar*, which can act individually or grouped (McGuirk, 2008). Calves have very small lungs compared to their body size so any episode of pneumonia causes a certain degree of permanent lung damage, making it difficult for the calf to thrive (Kasari, 1994). Calves most commonly get affected by pneumonia after a period of stress, such as weaning, dehorning, castrating, or transportation. Early detection of the disease is challenging. In the newborn calf, mucous membrane color, thoracic auscultation character and frequency of the respiratory effort and ability to oxygenate are critical elements of the clinical examination in order to determine whether or not respiratory disease is present (Poulsen and McGuirk, 2009). According to those mentioned before, it is desirable to take all the necessary measures as soon as possible to treat this episodes of disease, due to its very expensive cost of treatment and to decreased weight gain of the calves (Amir et al., 2013).

CONCLUSIONS

The neonatal period is the most critical phase in the dairy farming system, due to high morbidity rates (from 10.5 to 21.6%) and a mortality of 3.5%. Most issues are due to the inability of the newborn to adapt to the extra-uterine environment and take over the vital functions which were previously performed by the mother, such as thermoregulation, basic acid balance, cardiorespiratory functions, nutrition and development of the immune system.

Given that this is the most sensitive and fragile period of adaptation of the newborn to the environment, it is essential to possess knowledge of the physiology of the calf and mother in order to monitor the health and well-being of the calf. Thus, it is hypothesized that monitoring the physiological parameters and adaptations of newborn calves during the first four weeks of life, as well as the management conditions used are critical to the development of healthy stock and the farmers' productivity and income.

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