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The rumen as a health thermometer: importance of ruminal function to the metabolic balance in ruminants – mini review

Abstract

The importance of ruminants supporting the man has been explored since the beginning of the 20th century. Recent concerns have shown that to attend the future demand of animal protein for the next 30 years is necessary to increase production in more than double by 2050. Throughout the centuries intense changes in ruminant diets forced animals to develop adaptations of feed behavior and morphological modifications on digestion, inducing drastic modifications to the future evolutionary adaptations of ruminant digestive system and increasing the risk of ruminal/metabolic diseases. Studies of the relationships between behavior and animal health have raised debates of how to identify ill animals using approaches that measures rumination time to predict risk of metabolic disorders in a herd. Therefore, the analysis of behavioral elements as the rumination time could be used as a marker to foresee animals at risk of diseases, and as a first step to apply preventive veterinary practices in ruminant herds.

Keywords: ruminal physiology, rumination time, metabolic diseases, negative energy balance, feed behavior

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Abbreviations: HC, high concentrate; RT, rumination time; DMI, dry matter intake; NEB, negative energy balance

The role of ruminants on global food system

Since the beginning of the 20th century manuscripts explore the importance of ruminants supporting the man[1,2] and as a major global element in agricultural economy.[3–5] Recent studies have predicted that to reach the future demand of animal protein for the next 30years, it is necessary to increase animal protein production in more than double by 2050.[6–8] Recently we have reviewed ruminant adaptations and evolution throughout the centuries and the new scenario of diets provoking morphological changes in the digestion and feed behavior in domestic ruminants.[9] Hence, this new situation indicates that feeding a long-term high-concentrate (HC) diet, induces cellular damage on both ruminal and colonic epithelium in goats,[10] and in genes that regulate thickness of the ruminal epithelium in cows.[11] Therefore, despite the fact that dietary changes and nutritional shifts can increase the chance of ruminal/metabolic diseases, and may cause more drastic modifications to the future evolutionary adaptations of ruminant digestive system,[9,12] new approaches of evaluating ruminal behavior may be a strong marker to predict the risk of diseases and suitable herd welfare.[13–16] Hence, this review aims to provide recent information of the associations between ruminal behavior and metabolic disorders. In addition, show the relations among the new approaches of monitoring ruminal function, predicting the risk of diseases.

Variables that can influence rumination

The rumination process is essential to fore stomach animals as the key event to keep a perfect function of the pre-stomachs. This process works not only to break down fiber in forage feeds, but also to maintain several aspects of metabolic balance as; the ideal ruminal pH, ruminal turnover, re-absorption of nitrogen through the urea cycle, and as a sensible measurement of acceptable herd welfare.[13,17,18] Rumen motility can be divided into primary contractions, which affect the whole reticulorumen, and secondary movements, which affect only a part of the organ. The ruminal motions depends on the activity of the animal, whether eating, ruminating or resting, and it requires up to 50seconds to complete a total cycle.[18] The variability of negative influences in the normal functioning of the rumination process is caused by many factors including acute stress, ethological behavior, diet quality and composition, production level, climatic condition, reproduction and health status.[19–22] These variables can cause metabolic changes as a response, including reduction in blood flow to rumen epithelium and diminished rate of digesta in the gastrointestinal tract.[22–24] In cases of indigestible residues, reticulorumen mixing and rumination together promote its turnover, which, if allowed to accumulate, would clot the rumen. The consequence of these changes is a depression of rumination time (RT), which subsequently leads to a reduction of dry matter intake (DMI), followed by a decline in weight gain or milk yield.[18,25] These conditions when occurring in transition dairy cows, can result in a prolonged decrease in DMI around calving and may result in nonadaptive negative energy balance (NEB), which may lead to diseases related to the transitional period as subclinical ketosis, hypocalcemia, displaced abomasum, retained fetal membranes, and metritis.[14,26]

Rumination behavior and metabolic conditions

The associations among ruminal motions and metabolic disorders are progressively more intense as these circumstances are near to pregnancy. Reproduction status plays a pivotal role in diminishing the DMI as the transition period begins, dictating how intense and adaptable will be the NEB.[13,14,26] In small ruminants, the high prolific rate increases the risk of energy imbalance during the pre and post-partum, and the sum of a limited physical space in the pregnant abdomen, reduced DMI during this period, and changes to a HC diets are factors that limit and lessen rumen cycles.[19,27,28] Our

clinical observations during cesarean sections in obese sheep indicate evidences of a slight reduction on reticulorumen space in the abdomen due to the great amount of adipose tissue. During the left paralumbar fossa celiotomy and after gaining access to the abdomen, it was noted that the left flank has been partially taken by a portion of the duodenum covered by an extremely fat greater omentum. Despite the fact that obese condition directly affects glucose and insulin efficiency and increase the risk of metabolic disorder, the effects of a shrunken ruminal space due to accumulated fat in the abdomen raises a red flag on ruminal adaptations due to long-term HC diets.[9,29]

Measurements of cow behavior identify animals at risk for illness

Currently, studies of animal behavior are gaining attention because of the relationships between behavior and animal health. Debates of how to predict and identify ill animals in a herd, and how to apply preventive veterinary practices are active topics of research.[16] After the indications that rumination behavior may be a promising indicator of metabolic conditions, new methods to measure and evaluate herd performance have typically focused on feeding comportment in ruminants.[30] Therefore, the introduction of a novel method to indirectly measure RT, evaluates vocal signs and allows automatic measurement of RT to analyze rumination behavior in different environments.[13,22] Results of these studies found that cows with different health problems ruminate less then healthy cows, and therefore, there is a relationship between RT and metabolic conditions such as ketosis, hypocalcemia, and inflammatory blood markers around calving.[13,14,22,30]

Conclusion

The importance of ruminal cycling and motion is imperative not only for the animal's digestive physiology, but also as a function driven by the entire health status. The analysis of behavioral elements as the rumination time could be used as a marker to predict animals at risk of diseases, and as a first step to apply preventive veterinary practices in ruminant herds.

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Conflict of interest

Author declares that there is no conflict of interest.

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