Use of Technology to Detect Bovine Respiratory Disease in Cattle

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Current state of cattle management

In the United States, most dairy and finishing beef cattle are managed in concentrated animal feeding operations (Galyean et al., 2011; MacDonald et al., 2020). Intensification of animal agriculture offers potential benefits for economical and production efficiencies, but it also poses potential risks to animal health and welfare. Housing animals in larger groups makes identification of sick, injured, or poorly performing animals more challenging because detection of many diseases, such as bovine respiratory disease (BRD), often depends on observations of changes in the physical or behavioral states of animals. Advancements in technology are therefore needed to facilitate improvements in detection and treatment and to improve overall animal health and welfare.

Cattle health

Reductions in animal health lead to increased treatment costs, impaired production, and increased risk of co-morbidity and mortality. Bovine respiratory disease is a multifactorial condition caused by a variety of viruses and bacteria that results in the infection of the upper and/or lower respiratory tract. Due to multiple causes of the disease and variability in the severity of clinical symptoms, detection of BRD on farms can be complicated. Several studies have demonstrated that infection with BRD early in life reduces future growth (Thompson et al., 2006; Cramer and Ollivett, 2019), decreases reproductive success (Teixeira et al., 2017), and limits milk production (Dunn et al., 2018).

Cattle welfare

Animal health is a central component of all established scientific definitions and conceptions of animal welfare. Notably, the Five Freedoms for Animals (Brambell, 1965), the Three Circles Model of welfare (Fraser et al., 1997) and the Five Domains of Animal Welfare (Mellor, 2016) discuss the importance of health as foundational to overall welfare assessments. The World Animal Health Organization notes, “An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behavior, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment."

Based on that definition, BRD negatively impacts the welfare of cattle, especially given that symptoms of the disease include elevated respiratory rate, cough, fever, lack of appetite and depression. Welfare concerns increase when diagnosis and treatment of the disease are delayed, resulting in prolonged discomfort, distress or suffering. As previously noted, current methods of BRD detection that rely primarily on human observation can present challenges due to subjectivity, and immunoassay tests to detect BRD are suboptimal because of the expense, time between sampling and diagnosis, and expertise required to perform the tests.

Precision livestock farming, which aims to leverage technology to enhance animal production and resource utilization, increasingly incorporates use of automated, real-time monitoring technologies to facilitate detection of health and welfare problems of animals housed individually or in groups. For example, accelerometers have been used to monitor movement patterns associated with lameness in cattle, while other collars and tags track rumination patterns. Cameras are also increasingly used to monitor animal feeding and drinking behaviors, movement patterns, animal locations within the environment, and vocalizations and other sounds, while thermal sensors can be used to detect changes in animal body temperatures. All of that can be useful in identifying changes from normal patterns that might be associated with illness or injury (Erp-van der Kooij and Rutter, 2020). The application of such technologies to enhance detection and treatment of BRD warrants further consideration.

Use of technology to detect bovine respiratory disease

Several strategies have been developed to detect BRD in cattle based on the understanding of physiological and behavioral changes that occur in animals experiencing respiratory disease. Deviations in patterns of activity and rumination allow for detection of BRD three days prior to visible clinical signs (Marchesini et al., 2016). Symptoms of BRD include depression and lack of appetite, so the ability to use sensors that monitor activity (i.e., accelerometer or pedometer) or rumination (i.e., collars or ear tags) may allow for earlier detection of abnormal behavior. Wottlin et al. (2021) indicated that a reduction in step count had the highest accuracy in detecting animals with BRD compared to lying bouts, standing time, and motion index. However, they also noted substantial daily variation in behavior within individual animals. Therefore, information about changes in movement may be more useful when it is combined with additional information in the detection of BRD.

Cough monitoring technology has the ability to detect BRD in pens of cattle (Vandermeulen et al., 2016; Carpentier et al., 2018). There is a relationship between the number of calves diagnosed with BRD and the number of detected coughs (Carpentier et al., 2018). Cough monitoring technology relies on the ability to distinguish between coughing sounds and other environmental sounds. Thus, the technology may not be able to identify which animal is coughing but rather that, within a pen, there is at least one animal coughing, compared to a baseline rate. Monitoring coughing events in pens of cattle also demonstrated that there is diurnal variation in the timing of when animals cough throughout the day: more animals cough in the morning than in the afternoon (Vandermeulen et al., 2016). Humans are not able to constantly monitor animals, so consistent information throughout the day is impractical. A system that monitors cattle throughout the entire day may increase the ability to detect BRD in animals that do not display consistent symptoms.

Thoracic ultrasonography to detect lung consolidation is another technique that has been used for BRD detection. Using an ultrasound to visualize the lung field allows for the identification of lung consolidation or damaged lung tissue as a result of BRD. The lung field is scanned during thoracic ultrasonography. The technique has been validated against the calf respiratory scoring chart (Buczinski et al., 2015) and is highly correlated with necropsy results (Flöck, 2004). Animals with lung consolidation in the first 60 days of life have reduced survivability (Adams and Buczinski, 2015) and reduced reproductive success (Teixeira et al., 2017). Some beef and dairy operations are implementing thoracic ultrasonography at weaning or prior to transport as a way to identify those animals that are less likely to be successful. Each operation may use that information differently, but changes in the extent and severity of lung consolidation may help identify management opportunities to improve animal health and welfare.

Despite these advancements, timely and accurate detection of BRD and its cause(s) present ongoing challenges. A potential technology that may assist with this challenge is point of care sensors. Potentiometric biosensors, or a chemical sensor that measures the potential of an electrode system, are used for rapid disease diagnosis based on detection of redox reactions that are unique for each pathogen and antibody (Murphy et al., 2020). These potentiometric biosensors do not require expensive laboratory equipment and produce faster results than standard immunoassay tests, which are currently the most common method used for disease detection. Development and optimization of potentiometric sensors is ongoing; however, they do represent an opportunity to increase on-farm disease detection accuracy without the delays that occur when submitting samples for immunoassay analysis at a standardized laboratory (Tarasov et al., 2016).

Machine learning, or the development of computer algorithms that improve through exposure to more data, can increase accuracy and precision of technologies using behavioral measurements to detect BRD. There are platforms being commercially developed to integrate monitoring of heart rate, respiratory rate, temperature and cough signatures using a collar that the cow wears. The systems have a catalog of cattle sneeze and cough audio data to train the neural network and build a classification model. This allows the system to continue to improve disease detection based on learning what normal and abnormal sounds are associated with disease. While this sensor requires one collar per animal, it also integrates multiple data points and the algorithms developed to detect BRD can continue to evolve based on additional information gathered.

The pros and cons of technology use

One of the benefits of using technology to detect BRD is a more consistent and constant monitoring of animals, which is not currently feasible otherwise. With current observation methods of BRD detection (via tracking of behavioral signs and movement patterns), there is likely to be variation between people in how they detect the disease. Technology would not be subject to human variation and may also provide access to more information to aid in decision-making. Several of the technologies described provide more data than would traditionally be collected from animals, which may assist with evaluating environmental and management changes. Finally, the benefits of technology are increased speed and accuracy of diagnosis, and consequently, reduced disease transmission and more rapid, precise treatment of animals.

While there are many potential benefits of utilizing technology to diagnose BRD, there are certainly some drawbacks that must be considered as well. Increasing farm technology requires increased data monitoring and management skills, which may not be available at each farm. Secondly, the use of technology for diagnosis of disease may lead to the marginalization of farm workers (Hostiou et al., 2017). Many farm workers have specific training and expertise associated with diagnosis of abnormal appearance and behavior of animals; the use of technology may displace those specialized workers or make them feel less valued. Furthermore, it is likely that in order to realize maximal accuracy and precision of BRD diagnosis, integration of multiple technology systems will be required. Integration of multiple data sets requires additional technical skills or software that may not be available. The costs of the technology and analysis of the immense amount of data they may generate must also be considered. Finally, a potential concern is that if the technology systems fail, repairs and a return to normal operations may be beyond the farm management control.

Conclusions

Bovine respiratory disease is both an economically costly and important animal welfare concern for cattle in the United States and worldwide. The use of technology may aid in the speed and accuracy of BRD detection, thus reducing the negative impact of the disease. While these benefits have the potential to significantly improve animal health and welfare, technology must be developed with a clear understanding of the potential impacts on farms and ranches. It is also likely that no one technology will solve all of the problems associated with BRD, but rather the integration of several technologies may be needed to optimize strategies for accurate detection and treatment.

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