Application of remote sensoring technology for the early detection of bovine respiratory disease

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Abstract
Bovine respiratory disease (BRD) is highly prevalent in the postweaning stages of beef production. The innate ability of the bovine to conceal disease severely restricts human caretakers from identifying sick cattle accurately and early in the disease process. This challenge reduces the efficacy of current BRD detection methods while potentially reducing the effectiveness of contemporary therapeutic regimens. The Quantified Ag technology (QAg) is a novel automated disease monitoring system designed to collect animal activity and ear temperature to detect outlying conditions among individual animals. Pilot research indicates that the QAg technology can detect BRD two days earlier compared to traditional methods (i.e. human observation) while potentially optimizing the labor efficiency of BRD detection efforts.

Key words: bovine respiratory disease complex, diagnosis, treatment

Introduction
Bovine Respiratory Disease (BRD) continues to be the most prevalent infectious disease syndrome in the postweaning phase of beef production. The negative impact of BRD is attributed to an increase in treatment costs, reduced feed performance, carcass impacts and mortality. This disease complex is multifaceted and directly impacted by animal, environmental and pathogen related factors. Multiple estimates abound, but it is widely accepted that BRD poses a significant cost to the North American beef industry on an annual basis.

Part of the "animal" effect of the BRD complex is attributed to the predator/prey instincts of the bovine. Given that cattle are historically regarded as a prey species, a significant defense mechanism when sensing a potential threat is to convey health to that respective threat.[4] Current BRD detection regimens rely wholeheartedly on the observational skills of human caretakers. This evolutionary defense mechanism employed by the bovine creates a significant challenge when attempting to detect individual animals with BRD. Prior research employing Bayesian-modeling methods has estimated that current BRD detection regimens are highly inaccurate leading to a high proportion of false-negative and potentially false-positive diagnoses.[3,5] Additionally, true positive diagnoses are likely identified late in the disease process potentially limiting antimicrobial effects and disease recovery. This hypothesis is supported by prior research which has repeatedly observed an association between the presence of lung pathology at the time of slaughter and a reduction in weight gain.[1,2]

In addition to the challenges of accurately detecting BRD, the beef industry (and other industries) is also tasked with identifying and retaining labor resources. At this point in time, labor shortages have put added strain on production systems while compounding the already difficult task of identifying sick cattle.[7]

Early and accurate detection of BRD
Large efforts have been made in attempt to improve upon the current BRD diagnostic methodology and have been previously reviewed and summarized.[7] In an ideal scenario, an improvement in BRD detection practices would encompass the following characteristics:

1. Identification of animals that not only develop BRD but are likely to need therapy: This attribute reflects the observation that although pathogen (i.e. viral) exposure may be widespread, a proportion of infected animals will spontaneously cure. Ultimately, we want to avoid detecting and subsequently administering antimicrobials to animals that would not see benefit.
2. Identify animals not only more accurately but earlier in the disease phase: As discussed above, current BRD detection practices are inadequate. Improvement would reflect refining not only the overall accuracy of detection but also detection occurring earlier in the disease phase. In theory, this may maximize the potential of antimicrobial therapy thereby minimizing the negative impact of BRD. Additionally, animal welfare (i.e. reduced time to initiate therapy, identification of subclinical disease, and avoidance of applying stress to animals falsely diagnosed with BRD) and judicious antimicrobial use (administration of antibiotics to animals who are truly diseased) may be improved by this practice
3. Augmentation of available labor resources to maximize time efficiency: Across most industries, labor is critical to the day-to-day sustainment of a given business. An early BRD detection system would serve to not be a replacement for human labor; but rather to supplement those resources to maximize efficiency.

Overview of the quantified ag technology
The Quantified Ag (QAg) technology is composed of a wearable device (ear tag) that communicates with a centralized antennae and data repository. The tag collects biometric data from the animal composed of the animal's overall activity and temperature of the external ear canal. Those data are compiled and analyzed via machine-learning methods, considering not only the respective individual but the larger population data as well, to identify changes in the animal's health status. The read-range of the QAg antennae is estimated to be approximately 2 miles in distance. Although the focus is on BRD, it is recognized that there is a great deal of variability in disease manifestation from animal-to-animal. Therefore, the QAg technology was designed to identify "outliers" in the production system rather than to BRD specifically. Consequently, although BRD is likely to be the cause of an alert (due to prevalence), it is still necessary for human caretakers to rule out other potential infectious/non-infectious disease syndromes (e.g. lameness, bloat, calving, etc.).

Quantified ag data summary

A pilot program evaluating the relative value of the QAg technology was initiated in the fall of 2018. The study objective was to estimate potential value in the QAg technology's ability to detect animals with BRD compared to traditional BRD diagnostic methods (i.e. visual observation plus rectal temperature). In essence, traditional BRD detection methods were to be employed; however, the QAg technology data was captured on all individuals and evaluated in a retrospective manner.

The study population represented auction-market derived beef/beef-cross heifer calves (N=1,089) procured in the southern U.S. and transported to western Kansas. The processing regimen consisted of the following: a modified-live viral vaccine, ecto/endo-parasiticide, a growth-promoting implant, an abortifacient, an individual identification tag, antimicrobial metaphylaxis, individual body weight, and a PI-BVDV test. A QAg tag was applied to all calves; however, these data were not acted upon during the study but were captured and evaluated retrospectively. The study population averaged 601 lbs at arrival and were housed in 14 open-air dirt-floor pens with ~ 70 hd/pen. Calves were fed based on the normal practices of the study site. Any feed-additives were offered equally across all pens. Water was offered ad libitum throughout the study.

A 5-day post-metaphylactic interval was observed across all pens. The BRD case definition was as follows: calves exhibiting a clinical illness score (CIS) of 1 AND a rectal temperature of ≥ 104 °F, OR calves with a CIS of 2 or 3 regardless of rectal temperature. Those meeting the BRD case definition were treated up to 3 times with the following regimen: 1) Florfenicol, 2) Enrofloxacin, 3) Oxytetracycline. A 3-day post-treatment interval was observed between treatments 1 and 2 as well as 2 and 3. All pens were followed to closeout.

To provide the reader with context of the study population, closeout health and performance outcomes are displayed in Table 1. The proportion of animals similarly categorized (i.e. calves pulled by the pen rider and alerted by the QAg technology plus animals not pulled or alerted by the either method) was observed at 74.2% (Kappa = 0.24). Interestingly, this value is consistent with prior estimates of BRD detection accuracy by human caretakers.[3,5] Among this subpopulation of animals, the QAg technology would have identified these animals for further assessment 2 days earlier, on average, compared to the pen rider (range: 40 days prior to 30 days after pen rider identification). From a labor standpoint, pen riders entered all 14 pens on each day of the study (195 days). If the QAg technology had been used on this population, animal caretakers would have only entered 2 pens daily, on average, to remove, treat and return the individual animals alerted by the system.

Although this study provided very early evidence that the QAg technology can identify cattle earlier than traditional methods while potentially optimizing labor resources, it is still unknown what value this technology may fully bring to BRD management. Nonetheless, research is ongoing and early results are promising.

Conclusion

Cattle are highly adept at concealing clinical signs of disease thereby limiting the effectiveness of efforts of humans in detecting disease. The QAg technology is an automated disease detection technology designed to utilize animal biometric data to identify "outliers" earlier and more accurately compared to traditional means. Early studies indicate that the QAg technology can identify cattle with BRD 2 days earlier (on average) while potentially reducing labor burdens. Future research is necessary to estimate the value of an automated disease detection system in commercial feedlot production settings.

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Table 1: Model-adjusted least square mean (± standard error) outcomes among auction-market derived beef heifers monitored by traditional pen rider methods.

Outcome	Pen rider		
No. calves enrolled		1090	
No. pens		14	
Final no. calves enrolled		1088	
Days on feed		195	
Enrollment weight, lb	601.76	±	16.91
BRD first treatment, %	23.67	±	2.21
BRD second treatment, %	8.34	±	1.24
BRD third treatment, %	2.98	±	0.58
BRD first treatment success, %	58.41	±	3.40
BRD second treatment success, %	52.53	±	6.04
BRD third treatment success, %	35.69	±	8.93
BRD case fatality risk, %	13.79	±	3.03
No. antibiotic treatments, #/heifer sold	0.41	±	0.06
Overall mortality, %	4.39	±	1.02
BRD mortality, %	3.12	±	0.90
Digestive mortality, %	0.28	±	0.16
AIP mortality, %	0.16	±	0.16
Other mortality, %	0.55	±	0.22
BRD outs (deads + removals), %	3.35	±	0.97
Total outs (deads + removals), %	4.63	±	1.07
Final body weight, lb	1182.81	±	16.22
ADG (deads in), lb	2.74	±	0.09
ADG (deads out), lb	2.99	±	0.05
F:G (deads in)	6.88	±	0.25
F:G (deads out)	6.40	±	0.11