An Estimate of the Economic Gain from Selection to Reduce BRDC Incidence in Dairy Calves

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ABSTRACT: Bovine respiratory disease complex (BRDC) is a common cause of morbidity and mortality in cattle. The general research objective of this coordinated agriculture project (CAP) is to use genomic approaches to identify chromosome regions and genes associated with susceptibility to BRDC. The cost of BRDC losses in pre-weaned dairy calves varies depending on market conditions, individual farm operating costs and incidence rates across farms and time. This study estimates the economic value of the rate of genetic gain using two reported incidence rates. The economic estimates identify that up to a 16% improvement in net margin can be obtained by reducing BRDC incidence using the economic costs from a BRDC CAP study site. The value of the rate of genetic gain is \$0.13 and \$0.20 per head per year for incidence rates of 0.09 and 0.25 respectively, using phenotypic selection assumptions.
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Introduction

Bovine respiratory disease complex (BRDC) is the leading natural cause of death in dairy cattle, causing 255,900 calf deaths annually which represent 46% and 23% of all deaths in weaned and pre-weaned calves, respectively (USDA NAHMS 2006). Despite the extensive use of vaccines and antimicrobials, the morbidity and mortality rates from BRDC have not declined in dairy cattle. The lack of progress in reducing the BRDC incidence over the past twenty years demonstrates the need for additional approaches to control this multifactorial syndrome. Genomic selection tools offer a new approach that can be used to select for animals with reduced susceptibility to BRDC to elicit a permanent reduction in BRDC incidence.

Recent developments in bovine genomics and new genotyping platforms have identified a large number of the loci associated with susceptibility to a complex spectrum of known BRDC pathogens. Reducing the considerable animal morbidity, mortality, and economic losses associated with BRDC will require the simultaneous development of genomic tools to enable the selection of animals that are significantly less susceptible to disease.

Typically, cattle with BRDC have clinical signs that include fever, rapid breathing, repetitive coughing, nasal and/or eye discharge, diarrhea, dehydration, and appetite depression. Animals are more likely to be affected by BRDC when stressed by sudden changes in feed, crowding, temperature, transportation, and when clean air is contaminated with ammonia, dust and pathogens. Although the environment plays a major role in BRDC infection rates, evidence indicates that susceptibility to BRDC is also under genetic control from ongoing studies as part of the USDA Bovine Respiratory Disease Complex Coordinated Agricultural Project (BRD-CAP www.brdcomplex.org). This work was undertaken as a portion of the outreach component of the USDA funded integrated research project (USDA-NIFA-AFRI grant number: 2011-68004-30367) entitled the Integrated Program for Reducing Bovine Respiratory Disease Complex in Beef and Dairy Cattle. Agriculture and Food Research Initiative.

Materials and Methods

Susceptibility to BRDC in approximately 2800 pre-weaned Holstein calves at commercial calf raising facilities in California and New Mexico was identified using the BRDC diagnostic criteria of McGuirk (2008) (Neibergs et al. 2013). In the McGuirk system, clinical signs of fever, cough, nasal discharge, and either ocular discharge or the ear position or head tilt scores were each assigned values from 0 to 3 and summed. Only the higher score between ocular discharge and ear position/head tilt is used in the summation score. Animals with cumulative scores less than 5 were considered to be controls and those with scores greater or equal to 5 were considered cases. The distribution of clinical scores for the Holstein calves is shown in Table 1. All sampled controls were housed adjacent to cases in individual hutches to provide similar exposure to BRDC pathogens over time. A small percent (7.8%) of controls subsequently converted to cases and were assigned a case phenotype and a new control was matched to the converted case.

Table 1. Distribution of Preweaned Holstein Calves Clinical Scores at two sites based on criteria of McGuirk (2008).

Clinical Score* (Semi-quantitative ordered phenotype)	**% of Animals Receiving Score***		**Binary Phenotype**
	California	**New Mexico**	
	n=2013	n=767	
0	11.6	4.5	Control
1	28	16.3	Control
2	11	21.4	Control

3	2.9	6.8	Control
4	0.4	0.7	Control
5	12.1	1.7	Case
6	13.1	3.6	Case
7	10.1	9.9	Case
8	6.3	11.6	Case
9	3.3	13.4	Case
10	0.9	6	Case
11	0.2	3.5	Case
12	0.1	0.6	Case

*0 represents no clinical signs of BRDC

The economic cost of BRDC in pre-weaned calves was estimated at the California study site involving approximately 1000 affected cases and 1000 unaffected control Holstein calves. At this facility, calves arrived in the first 2-3 days of life and were placed into hutches with slatted floors. Calves were weaned at approximately 70 days. BRDC losses included mortality, treatment, and lost productivity. The cost of BRDC in this study was estimated to be $20.43 per affected animal.

Heritability estimates were obtained by genomic best linear unbiased prediction (GBLUP) and efficient mixed model association eXpedited (EMMAX) from genotypes of the Holstein calves obtained with the Illumina 778K Bovine HD BeadChip. Sex and age were used as covariates in these analyses. The GBLUP heritability estimate for BRDC was 21.5% for the California calves and the pseudo-heritability estimate from EMMAX was 21% for the California calves. Similar heritability estimates of 21% were obtained when the New Mexico calves were genotyped and analyzed. Regardless of the method used, the heritability estimates for BRDC are in the moderate range (Neibergs et al. 2013). This suggests that selection for cattle that have reduced susceptibility to BRDC could be used to reduce BRDC incidence.

The classic equation for estimating the rate of genetic change, as described by Falconer (1989), is:

$$\Delta BV/_t = \frac{ir\sigma_a}{L}$$

where ΔBV/t is the rate of genetic change per unit of time, which in this application represents the reduction in BRDC incidence in pre-weaned dairy calves, i is the standardized selection intensity, r is the accuracy of selection, σ_a is the additive genetic standard deviation of the trait of interest, and L is the generation interval in years.

The following parameters were assumed to estimate the model. There is no clear point of truncation for reduced disease susceptibility. On commercial dairy farms, the supply of heifer calves will not be much greater than the number needed to be raised as replacement animals. In a typical dairy farm the cow culling rate is 33%. If sexed-semen is not used and half of the calves are heifers, then 67% of the heifers would need to be retained to maintain a constant herd size. This corresponds to a standardized selection intensity coefficient of 0.542. The accuracy of selection is assumed to equal the square root of the heritability for BRDC (46%) that would be realized from phenotypic selection. This would form a conservative estimate for the accuracy of prediction of molecular breeding values for susceptibility to BRDC. The genetic standard deviation for BRDC incidence is based on the following assumptions and calculations: BRDC incidence in dairy calves will vary between operations, seasonally and annually. Two studies report BRDC incidence in dairy calves at 9% (Walker et al. 2012) and 25% (Windeyar et al. 2012). The REML estimates of additive genetic variance from the GBLUP analysis of the California calves with a incidence of 50% was $V_A = 0.0535$ and the phenotypic variance was $V_P = 0.2487$. The binomial phenotypic variance of BRDC susceptibility with a incidence rate of (p) can be calculated as p(1-p) and, assuming that heritability is constant (independent of p), the additive genetic variance for a incidence p is $V_A = h^2p(1-p)$. Thus, for a heritability of 0.215, the additive standard deviations for incidence rates of 9% and 25% are $\sigma_a = 0.1327$ and 0.2008, respectively. The generation interval (L) for dairy cows was estimated at 5 years. Biologically, the shortest possible generation interval is the sum of age at sexual maturity and gestation length, or approximately 2 years of age in dairy cattle. Generation interval can be shortened by using advanced reproductive technologies such as embryo transfer and *in vitro* fertilization, but these practices are not commonly used in commercial dairy cattle breeding programs.

Results and Discussion

Table 2 presents the rate of genetic change for the two BRDC incidence rates. For BRDC incidence rates of 0.09 and 0.25, the rates of genetic change were 0.0067 and 0.0101, respectively. Incidence rates of BRDC vary by operations, season and years. The two incidence rates reflect a range so as to evaluate the associated economic gain from selection for reduced BRDC susceptibility.

Table 2. Calculated Rate of Change in Breeding Value for BRDC

BRDC incidence	0.09	0.25
Heritability	0.215	0.215
Accuracy = square root heritability	0.46	0.46
Selection intensity	0.542	0.542
Additive genetic variance	0.1327	0.2008
Generation interval	5	5
Change in BV - reduction in BRDC incidence	0.0066	0.0100

Estimates of the economic cost of BRDC in young dairy calves are scarce. One study provided cost estimates of respiratory disease in young dairy stock that ranged from $0.90 to $3.98, with an average of $1.95 per head (Kaneene and Hurd 1990). Using the economic loss in the BRD-CAP California study of $20.43 per affected animal, this corresponds to a BRDC cost per animal on the entire growing facility of $1.84 for the 0.09 incidence rate and of $5.11 for the incidence rate of 0.25. Although these economic cost estimates seem low, they are economically significant when multiplied by the large number of calves on commercial dairy raising facilities and the low to negative profit margin of a calf growing enterprise from birth to weaning. Additional BRDC economic losses have been reported to occur from weaning through first lactation. Data on this production phase are in the process of being collected through the BRDC–CAP project but are not yet available.

The net margin from raising calves to weaning is highly variable across operations and time due to variation in feed, labor, cost of the calf, fixed costs and weaned calf value. The net margin on weaned dairy calves at the California project site at the time of the study was a loss of $25 per head. By reducing BRDC incidence and thus economic losses, the net margin could be increased by as much as 16% by reducing the high 0.25 incidence rate to 0.05. As calf values increase due to market conditions, the economic return gained by reducing BRDC incidence increases. Reducing BRDC incidence is one of the few items that can easily be targeted by selection to improve profitability. The application of genomic selection to reduce BRDC incidence is a cost effective approach to decrease morbidity and mortality in dairy cattle.

The rate of genetic gain in reducing BRDC incidence was estimated using the most conservative assumptions on selection intensity, accuracy and generation interval. The economic value of the rate of genetic gain was $0.13 and $0.20 per head per year for incidence rates of 0.09 and 0.25, respectively. With a current inventory of over 9 million lactating dairy cows in the United States alone, this would represent an economic gain of $1.17M to $1.80M annually through selection of cattle that are less susceptible to BRDC. The economic value of genetic gains in BRDC susceptibility could increase as accuracy increases, as would be expected when information on BRDC breeding values of animals within their pedigrees have been determined. Additionally, the generation interval can be reduced by making selection decisions using genetic markers at a young age, rather than after progeny are born.

Conclusions

Recent developments in bovine genomics have identified a large number of the loci associated with susceptibility to a complex spectrum of known BRDC pathogens. The economic cost of BRDC in pre-weaned dairy calves is not large per head but when aggregated in commercial operations it has a substantial economic effect. This paper identifies that calf production net margins could be increased by up to 16% by reducing BRDC incidence to 0.05. Selection offers a viable tool to make economic progress by reducing BRDC incidence.

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