Economic Effects of Bovine Respiratory Disease on Feedlot Cattle during Backgrounding and Finishing Phases

Kathleen Brooks
Department of Agricultural Economics
Oklahoma State University
521 A Agricultural Hall
Stillwater, OK 74078
405-744-9985
Email: kblubau@okstate.edu

Kellie Curry Raper
Department of Agricultural Economics
Oklahoma State University
514 Agricultural Hall
Stillwater, OK 74078
405-744-9819
Email: kellie.raper@okstate.edu

Clement E. Ward
Department of Agricultural Economics
Oklahoma State University
513 Agricultural Hall
Stillwater, OK 74078
405-744-9821
Email: clement.ward@okstate.edu

Ben P. Holland
Willard Sparks Beef Research Center
Oklahoma State University
Stillwater, OK 74078
405-377-8501
Email: ben.holland@okstate.edu

Clint Krehbiel
Department of Animal Science
Oklahoma State University
208 Animal Science Building
Stillwater, OK 74078
405-744-8857
Email: clint.krehbiel@okstate.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia, January 31-February 3, 2009

Abstract

This research examines the economic effects of bovine respiratory disease (BRD) on backgrounding and finishing phases of cattle production. This research measures the effectiveness of using serum haptoglobin (Hp) concentration to predict BRD occurrence and the impact of multiple treatments for BRD infection on cattle performance and returns. During the backgrounding phase, 222 heifers were grouped by Hp level. After the backgrounding phase, 193 heifers were then grouped by number of BRD treatments in the finishing phase. Net returns decreased in the backgrounding phase and the combined phases as the number of BRD treatments increased. Hp concentrations had no significant effects on net returns.

Key Words: bovine respiratory disease, haptoglobin, net returns

Introduction

Bovine respiratory disease (BRD) is the most common disease among feedlot cattle in the United States. It accounts for approximately 75% of feedlot morbidity and 50 to 70% of all feedlot deaths (Edwards, 1996; Galyean, Perino, and Duff, 1999; Loneragan et al., 2001). The majority of deaths due to BRD occur shortly after arrival to the feedlot or within the first 45 days (Loneragan et al., 2001; Edwards, 1996). In fact, Buhman et al. (2000) reported that about 91% of calves diagnosed with BRD were diagnosed within the first 27 days after arrival. BRD causes an estimated \$800-\$900 million annually in economic losses from death, reduced feed efficiency, and treatment costs (Chirase and Greene, 2001). Although medical costs attributable to the treatment of BRD are substantial, the economic impacts of BRD on carcass merit and meat quality further increase the economic costs.

Gardner et al. (1999) found steers with lung lesions plus active lymph nodes had \$73.78 lower net return, with 21% attributable to medicine costs and 79% due to lower carcass weight (8.4% less) and lower quality grade (24.7% more USDA Standard quality grade carcasses). BRD can also cause economic losses due to decreased gain and carcass values (Duff and Galyean, 2007). A Texas Ranch-to-Rail study found BRD morbidity accounted for 8% higher production costs, not including losses related to decreased performance (Griffin, Perino, and Wittum, 1995). They found cattle with BRD had a 3% decrease in gain compared with non-sick cattle and cost the program \$111.38 per dead animal. Snowder et al. (2006) estimated economic losses in a 1000 head feedlot from BRD infection due to lower gains and treatment costs to be approximately \$13.90 per animal.

Demand for higher quality products and increased value-based marketing have heightened beef producers' awareness of health management practices with potential to increase profitability and beef product quality. Feedlot producers able to purchase calves that are more likely to remain healthy during the feeding period could potentially increase profits through reduced costs and higher revenues. Previous studies document the economic impact from BRD in either backgrounding or finishing programs. The overall objective of this research is to determine the economic effects of BRD on both backgrounding and finishing phases and the two phases combined for the same cattle. In addition, this research measures the effectiveness of using serum haptoglobin (Hp) concentration to predict BRD occurrence and the impact of multiple treatments for BRD in the backgrounding feedlot cattle performance.

Conceptual Farmework

Cattle producers are assumed to maximize expected profits. The question is whether the use of serum Hp concentration to predict BRD occurrence has an effect on those expected profits and whether multiple treatments for BRD affect the returns on infected cattle.

Producers' objective function can be written for a margin enterprise like backgrounding and cattle feeding as:

(1) $$\max_x \mathrm{E}(margins) = \boldsymbol{P}'\boldsymbol{Y}(\boldsymbol{x}) - \boldsymbol{r}'\boldsymbol{x}$$

where $\mathrm{E}(\pi)$ is the expected profit per head from their operation, P is the vector of output prices, $\boldsymbol{r}$ is the vector of input prices, $\boldsymbol{Y}(\boldsymbol{x})$ is the final weight of cattle produced, and $\boldsymbol{x}$ is the vector of inputs.

Equation (1) does not consider the Hp risk group. Cattle producers' would want to maximize expected net returns subject to costs and the Hp risk group. Hp is an acute-phase protein produced by the liver in response to cellular injury. Serum Hp concentration has been suggested as a tool for making management decisions based on data that shows cattle requiring treatment for BRD had a higher Hp concentration upon arrival than calves that remained healthy throughout the preconditioning phase (Berry et al., 2005). Producers could test serum Hp prior to purchasing calves to estimate their Hp risk group. This would give the formula:

(2) $$\max_{x,v} \mathrm{E}(margin) = \max\{\boldsymbol{P_v}'\boldsymbol{Y_v}(\boldsymbol{x}) - \boldsymbol{r}'\boldsymbol{x_v} | v = 1, 2, 3\}$$

where E(π) is expected profit per head from the operation, $\boldsymbol{P_v}$ is the vector of expected prices for risk group *v* (*v*=1, 2, 3), $\boldsymbol{r}$ is the vector of input prices, $\boldsymbol{Y}(\boldsymbol{x})$ is the final weight or number of cattle produced in risk group $\boldsymbol{v}$, and $\boldsymbol{x}$ is the vector of inputs for risk group $\boldsymbol{v}$. The producer would then be maximizing net margins per head.

Data

Backgrounding phase

For this study, 222 cross-bred heifers were purchased by Eastern Livestock order buyers and assembled at the West Kentucky Livestock Market, Marion, KY. Heifers were processed after arrival to Stillwater, OK (day 0) and assigned pens according to Haptoglobin (Hp) concentration: Low (serum Hp<1.0 mg/dL), Medium (1.0 mg/dL <serum Hp<3.0 mg/dL), and High (serum Hp>3.0 mg/dL). Of the 222 heifers, 53 (23.9%) were in the low risk group, 66 (29.7%) were in the medium risk group, and 103 (46.4%) were in the high risk group. Heifers were fed twice daily, ad libitum, a 65% concentrate receiving/growing ration during the 63-day backgrounding phase. Heifers were evaluated daily for signs of BRD (depression, lack of fill compared with penmates, cough, nasal or ocular discharge, altered gait, etc.) and were treated according to treatment protocol. Of the 222 heifers, there were a total of 54 never treated (24.3%), 54 treated once (24.3%), 34 treated twice (15.3%), 39 treated three times (17.6%), 12 classified as chronics (5.4%), and 29 that died (13.1%) during the backgrounding phase.

Heifers were individually weighed on days 0, 7, 14, 21, 42, and 63. Production data included average daily gain (ADG) during the 63-day backgrounding phase, feed intake and costs, vaccination costs, feed conversion, Hp risk group, number of BRD treatments, and cost of BRD treatments. The initial price and day 63 price were estimated using USDA Agricultural Marketing Services (AMS) sale data for the same dates at the Oklahoma City market, with adjustments for weights.

Finishing phase

After the backgrounding phase (63 days), heifers were allocated to finishing pens based on the number of times they were treated for BRD. There were 6 heifers per pen except three pens of those treated three times had 7 heifers per pen. Initial classification based on arrival serum Hp was disregarded at this time. Only 193 heifers from the backgrounding phase were also in the finishing phase due to 29 (13%) dying in the backgrounding phase. Of the 193 heifers, 54 (28.0%) had zero treatments, 54 (28.0%) had one treatment, 34 (17.6%) had two treatments, 39 (20.2%) had three treatments, and 12 (6.2%) were classified as chronics. Animals were considered chronically ill if they had been assigned a BRD severity of ≥3, had a net weight loss over at least 21 days in the backgrounding phase, and had been given all available antimicrobials according to protocol. Severity scores were based on their signs of BRD (see above). Severity scores were on a scale from 1 to 4. Cattle were fed according to standard procedure at the facility and weighed every 28 days.

Finishing phase production data included ADG, feed intake and cost, vaccination costs, feed conversion, and total days on feed. Heifers were harvested in three groups at the end of the feedlot phase (152, 174, or 189 days on feed). Harvest dates were based on live weight and estimated carcass backfat of 0.4 inches using ultrasound. All chronics were harvested on the final date (189 days on feed). Carcass data included marbling, yield grade, hot carcass weight (HCW), and back fat measurement. Heifers were priced on a grid using the packing plant's grid. Estimated prices were also calculated using AMS data but were found to not be significantly different from the packing plant's grid prices (National Weekly Direct Slaughter Cattle-Premiums and Discounts).

Summary statistics on data collected are shown in Table 1. During the finishing phase 4 more animals died, 2 of which were from the chronics group. Four heifers that did not die during the finishing phase are not included in final statistics because they had incomplete carcass data.

Data are used to determine the effects of Hp risk groups for BRD, treatment of sick animals, and the risk-treatment interaction on net returns, costs, and animal performance for the backgrounding phase, the finishing phase, and the backgrounding and finishing phases combined.

Procedure

One objective was to determine mean differences across risk group and number of BRD treatments for different production characteristics. The performance and net return differences were analyzed using Least Squares Means (LS Means) and the following model:

(3) $$Z = \alpha_0 + \sum_{i=1}^{2} \alpha_i RG_i + \sum_{j=1}^{3} \beta_j C_j + \sum_{i=1}^{2} \sum_{j=1}^{3} \alpha_{ij} RG_i\, C_j$$

where Z is the independent performance measure, RG_i is the risk group *i* (*i*=1, 2), and C_j is the number of BRD treatments *j* (*j*=0, 1, 2, 3). Performance measures included ADG, feed-to-gain conversion, feed costs, day 63 weight, and number of BRD treatments for the backgrounding, finishing, and the phases combined. Carcass measures included hot carcass weight (HCW), marbling score, and yield grade. Net returns for the backgrounding, finishing, and the two phases combined were also analyzed. Feed conversion is the amount of feed consumed per pound of gain. Feed conversion was calculated by dividing total amount of feed intake (as fed) per animal by total pounds gained per animal.

Another objective was to determine the most important factors affecting net returns. Of interest are the relative effects of each regressor on net returns.

(4) $$\mathrm{E}(NR_{jit}) = \beta_{j0} + \beta_{j1}x_1 + \beta_{j2}x_2 + \cdots + \beta_{jn}x_n + \varepsilon_{jit}$$

where $\mathrm{E}(NR_{ji})$ is the net revenue per head to be estimated, $\beta's$ are the estimated standardized betas, and the x_i are the variables used for the standardized betas, with *i* representing the individual heifer, *j* represents either the backgrounding phase, the finishing phase, or the total, and, $\varepsilon_{jit}$is the residual error term.

The units of the variables in equation (4) are different; therefore the magnitudes of the individual regression coefficients cannot be directly compared. For comparison, variables were normalized to have a mean of zero and a variance of one. Regressing these variables on the normalized net returns yields standardized beta coefficients (SBC). SBCs were calculated from a regression model to determine the influence of the each variable on net returns. Standardized beta coefficients were calculated for net returns using the following model:

(5) $$\frac{NR-\overline{NR}}{\sigma_Y} = \sum_i \beta_i^* \frac{x_i - \bar{x}}{\sigma_{x_i}} + \epsilon$$

where *NR* is the net revenue, σ is the standard deviation, x_i is the *i*th independent variable of interest, and β_i^* is the SBC for the *i*th independent variable. The new coefficients are calculated:

(6) $$\beta_i^* = \beta_i \frac{\sigma_{x_i}}{\sigma_Y}.$$

The SBCs are proportions and can therefore be used to rank the relative importance of the independent variables. Coefficients are interpreted such that if x_1 increases by one standard deviation, then *Y* changes by β_1^* standard deviations (Wooldridge, 2006).

The variables for the backgrounding phase included initial body weight (IBW), average daily gain (ADG), feed conversion, BRD treatment costs, feed costs on as fed basis, Hp risk group, and the number of BRD treatments. Variables for the finishing phase included initial finishing phase body weight, ADG in the finishing phase, feed conversion, feed costs on as fed basis, hot carcass weight, marbling score, yield grade, Hp risk group, and number of BRD treatments. The combined phase included IBW, ADG for the entire trial, feed conversion, BRD treatment costs, total feed costs on as fed basis, hot carcass weight, marbling score, yield grade, Hp risk group, and number of BRD treatments.

Net revenue was calculated for the backgrounding phase by subtracting from the transfer revenue/cost, purchase cost of the calves, BRD treatment costs, vaccination costs, and feed costs in the backgrounding phase. Vaccination costs varied depending on the initial body weight of the animals. All BRD treatment costs were incurred during the 63-day backgrounding phase.

Average net revenues for the backgrounding, finishing, and combined phases can be found in Table 2. The net revenue for the finishing phase was calculated by subtracting transfer revenue/cost, vaccination costs, and feed costs for the finishing phase from ending revenue. The total net revenue was calculated by subtracting placement cost, all vaccination costs, feed costs, and BRD treatment costs from ending revenue. The transfer revenue/cost was defined as $/head at the end of the backgrounding phase and the beginning of the finishing phase. Ending revenue is $/head based on grid prices. All net revenues were calculated independent of market conditions. Average margin per head attributed to deads in the backgrounding phase and the combined phases was calculated. These were calculated by taking the average net returns per head for that phase times 222 heifers minus the average net returns for deads times 29. The differences was then subtracted and multiplied by 193 and yielded the average margin per head attributed to deads.

Results

Least squares means

Least squares means by Hp risk group are in Table 3. No significant differences were found across risk group for any of the net returns. Hp risk group one was significantly different (probability less than 0.05) than risk group three for marbling score. Risk group one and three were also significantly different for background feed:gain conversion. Wittum and Perino (1995) also found Hp concentration unrelated to severity of the case or the need for treatment in feedlot cattle. However, Hp has been found to have some value in assessing treatment efficacy (Carter et al., 2002; Wittum et al., 1996)

Least squares means by the number of BRD treatments received are in Table 4. Beginning weight was not statistically significant at P-value 0.05 across BRD treatments; however weight at end of background phase and the start of the finishing phase was significantly different across all treatment groups. Heifers classified as chronics in the backgrounding phase gained 2.25 lbs/day, 1.72 lbs/day, and 1.40 lbs/day less than heifers never treated, treated once, or twice, respectively. During the finishing phase, heifers with one, two or three BRD treatments gained 0.42 lbs/day, 0.48 lbs/day, and 0.58 lbs/day, respectively, compared to chronic heifers. Buhman et al. (2000) also reported heifer calves had a lower mean daily gain when sick calves were compared with those not sick or not removed for treatment. Gardner et al. (1999) showed similar results of increased average daily gain for steers never treated compared to those treated once or more than once (Gardner et al., 1999; Wittum and Perino, 1995). The BRD incidence occurred during the backgrounding phase. Early detection and proper treatment could contribute to the calf's recovery and compensatory gain during the finishing phase. Similar research found that compensatory gain was evident in the feedlot after proper treatment for BRD (Snowder et al., 2006).

Cost of gain increased as the number of BRD treatments increased during the preconditioning phase and was significantly different from cattle that died. During the finishing phase cost of gain per head for those never treated or treated once was significantly higher than the cost of gain for those treated three times or classified as chronics. Figure 1 shows the cost of gain across the number of BRD treatments for all three phases.

As the number of BRD treatments increased, the cost of BRD treatment increased significantly. Those never treated were significantly different (probability less than 0.05) than those treated at least once. Those never treated averaged $0.27 per head in BRD treatment costs while those treated three times or considered chronic had over $35 per head in BRD treatment costs. Those treated three times or those considered chronic were not significantly different. As the number of BRD treatments increased, backgrounding net returns decreased significantly. On average heifers with zero treatments had $114.62

higher net returns compared to heifers classified as chronics. Heifers treated once, twice, or three times had $87.94, $66.50, and $24.78, respectively, higher backgrounding net returns than chronics. There was an average death loss of $661.92 in the backgrounding phase. No significant differences were found in finishing phase net returns across BRD treatments. Figure 2 shows the net returns across the number of BRD treatments for all three phases. Overall, heifers classified as chronics had significantly lower compared to those with zero, one, or two treatments. Chronic heifers lost significantly more ($143.28) than those with zero treatments and $132 more than those treated once or twice. Overall chronics and heifers treated three times were not significantly different at $P<0.05$. Similar findings have showed calves never treated for BRD had significantly higher returns than calves treated once or more than once (Fulton et al., 20002). BRD treatment costs have been found to range from zero to $21.70 per head (Edwards, 1996; Fulton et al., 2002).

Background phase model

The purpose of the regression models was to determine the most important factors affecting net returns. The background phase net returns model estimated coefficients are in Table 5. The independent variables in the model explained 99% of the model. Coefficients for initial body weight, ADG, feed conversion, BRD treatment costs, and feed costs were all significant at the 5% level. As initial body weight, feed: gain conversion, BRD treatment costs, and feed costs in the backgrounding phase increase, net returns decreased by $0.34, $0.09, -$1.16, and -$0.76, respectively. The coefficients Hp risk groups 1 and 2 were not significantly different from risk group three. The number of BRD treatments was significantly different than heifers that died at $P<0.0001$.

Standardized beta coefficients determine the influence of the variables on net returns. The standardized beta coefficient (SBC) for backgrounding ADG demonstrates that a one standard deviation change in ADG results in a 0.061 standard deviation change in backgrounding net returns. The number of BRD treatments is significant and positive. The SBC indicates that standard deviation increases by 1.131, 1.130, 0.949, 0.989, and 0.565 for every one standard deviation change in those animals never treated, treated once, twice, three, or classified as chronics, respectively. Compared to the net returns of animals that died, net returns increase with fewer BRD treatments. Initial body weight, feed:gain conversion, BRD treatment costs, and cost of feed all decrease the standard deviation.

Finishing phase model

The finishing phase net returns model estimated coefficients are in Table 6. The independent variables in this model explained 53.6% of the model. The initial placement weight into the feedlot, feed cost, HCW, and yield grade coefficients were all significant at the 5% level. The initial placement weight, feed costs, and yield grade all significantly (P-values <.0001, 0.005, and 0.001, respectively) decreased finishing phase net returns by \$0.90, \$0.53, \$16.88, respectively. HCW significantly (P-value <.0001) increased net returns by \$1.45.

Standardized beta coefficients for the finishing phase are also in Table 6. The HCW standardized beta coefficient indicates HCW had the highest positive influence on finishing net returns (0.870). The initial weight in the finishing phase had the highest negative influence on finishing net returns (-0.623). Hp risk groups 1 and 2 were not significantly different from risk group 3. The number of BRD treatments was not significantly different from the net returns of chronics.

Overall model

The overall net returns model estimated coefficients are in Table 7. The independent variables in this model explained 55.4% of the model. The initial body weight, backgrounding feed costs, HCW, and yield grade coefficients were all significant. Initial body weight significantly decreased overall net revenues by \$0.85 (P-value <.0001). Net returns decreased by \$1.92 as backgrounding feed costs increased (P-value 0.05). Hot carcass weight increased net returns by 1.36 while yield grade decreased it by $17.84 (P-value <.0001 and 0.005, respectively). Heifers treated once or twice had overall net returns that were significantly different (P-value 0.03 and 0.03, respectively) compared with those that had died. Those heifers never treated were significantly different at the 10% level compared with the net returns of heifers that died.

Standardized beta coefficients for the overall net returns indicate that HCW has the highest positive influence (0.781). The standardized estimate for those treated for BRD zero, once, or twice are all significantly positive (0.545, 0.504, 0.232, respectively) compared to the heifers that died. As the number of BRD treatments increases overall net returns decrease.

Summary and Conclusions

The overall objective of this research was to determine the economic effects of bovine respiratory disease (BRD) on both backgrounding and finishing phases and on the two phases combined. In addition, this research measured the effectiveness of using serum haptoglobin (Hp) concentration to predict BRD occurrence and the impact of multiple treatments for BRD on cattle performance and net returns.

BRD treatment costs were significantly higher for chronic heifers compared with those receiving two or fewer BRD treatments. Net returns decreased per head, as the number of BRD treatments increased in the backgrouning phase and the combined phases. Previous research found similar results (Edwards, 1996; Fulton et al., 2002). In the finishing phase, net returns were not significantly different as the number of BRD treatments increased. The heifers classified as chronics tended to catch up to those receiving three or less treatments. Approximately $29 is the average margin/head attributed to deads in the backgrounding phase. Overall, there is $116 attributed to deads for the average margin per head. That means for every animal that died there was $116 less in the average margin.

Backgrounding phase cost of gain was significantly different between heifers in risk group three compared with risk groups one and two. Further studies need to be conducted to further examine the economic efficiency of using Hp concentration to predict the number of BRD treatments.

The research presented here was conducted on heifers only. Further research should address whether differences exist in the impact of BRD treatments between heifers and steers in the backgrounding, finishing, and combined research. Further research is also needed to determine differences in Hp concentration on predicting BRD treatments in both steers and heifers.

References

Berry, B.A., A. W. Confer, C.R. Krehbiel, D.R. Gill, R.A. Smith, and M. Montelongo. "Effects of Dietary Energy and Starch Concentrations for Newly Received Feedlot Calves: II. Acute-Phase Protein Response." *Journal of Animal Science* 82(2004): 845-850.

Buhman, M.J., L.J. Perino, M.L. Galyean, T.E. Wittum, T.H. Montgomery, and R.S. Swingle. "Association Between Changes in Eating and Drinking Behaviors and Respiratory Tract Disease in Newly Arrived Calves at a Feedlot." *American Journal of Veterinary Research* 61(2000):1163-1168.

Carter, J. N., G. L. Meredith, M. Montelongo, D. R. Gill, C. R. Krehbiel, M. E. Payton, A. W. Confer. "Relationship of Vitamin E Supplementation and Antimicrobial Treatment with Acute-Phase Protein Responses in Cattle Affected By Naturally Acquired Respiratory Tract Disease." *American Journal of Veterinarian Resources* 63(2002):1111-1117.

Chirase, N.K., and L.W. Greene. "Dietary Zinc and Manganese Sources Administered from the Fetal Stage Onwards Affect Immune Response of Transit Stressed and Virus Infected Offspring Steer Calves." *Animal Feed Science and Technology* 93(2001):217-228.

Duff, G.C., and M.L. Galyean. "Board-Invited Review: Recent Advances in Management of Highly Stressed, Newly Received Feedlot Cattle." *Journal of Animal Science* 85(2007):823-840.

Edwards, A.J. "Respiratory Diseases of Feedlot Cattle in the Central USA." Bovine Practitioner 30(1996):5-7.

Fulton, R.W., B.J. Cook, D.L. Step, A.W. Confer, J.T. Saliki, M.E. Payton, L.J. Burge, R.D. Welsh, K.S. Blood. "Evaluation of Health Status of Calves and the Impact on Feedlot Performance: Assessment of a Retained Ownership Program for Postweaning Calves." *The Canadian Journal of Veterinary Research* 66(2002):173-180.

Galyean, M.L., L.J. Perino, and G.C. Duff. "Interaction of Cattle Health/Immunity and Nutrition." *Journal of Animal Science* 77(1999):1120-1134.

Gardner, B.A., H.G. Dolezal, L.K. Bryant, F.N. Owens, and R.A. Smith. “Health of Finishing Steers: Effects on Performance, Carcass Traits, and Meat Tenderness.” *Journal of Animal Science* 77(1999):3168-3175.

Griffin D., L. Perino, and T. Wittum. “Feedlot Respiratory Disease: Cost, Value of Preventives and Intervention.” *Proceedings of the American Association of Bovine Practitioner* 27(1995):157-160.

Loneragan, G.H., D.A. Dargatz, P.S. Morley, and M.A. Smith. “Trends in Mortality Ratios Among Cattle in US Feedlots.” *Journal of the American Veterinary Medical Association* 219(2001):1122-1127.

Snowder, G.D., L.D. Van Vleck, L.V. Cundiff, G.L. Bennett, M. Koohmaraie, and M.E. Dikeman. “Bovine Respiratory Disease in Feedlot Cattle: Phenotypic, Environmental, and Genetic Correlations with Growth, Carcass, and Longissimus Muscle Palatability Traits.” *Journal of Animal Science* 85(2007):1885-1892.

Wittum, T.E. and L.J. Perino. “Passive Immune Status at Postpartum Hour 24 and Long-Term Health and Performance of Calves.” *American Journal of Veterinary Research* 56(1995):1149-1154.

Wooldridge, J. M. *Introductory Econometrics: A Modern Approach*, 3rd ed. Ohio: Thomson South-Western, 2006.

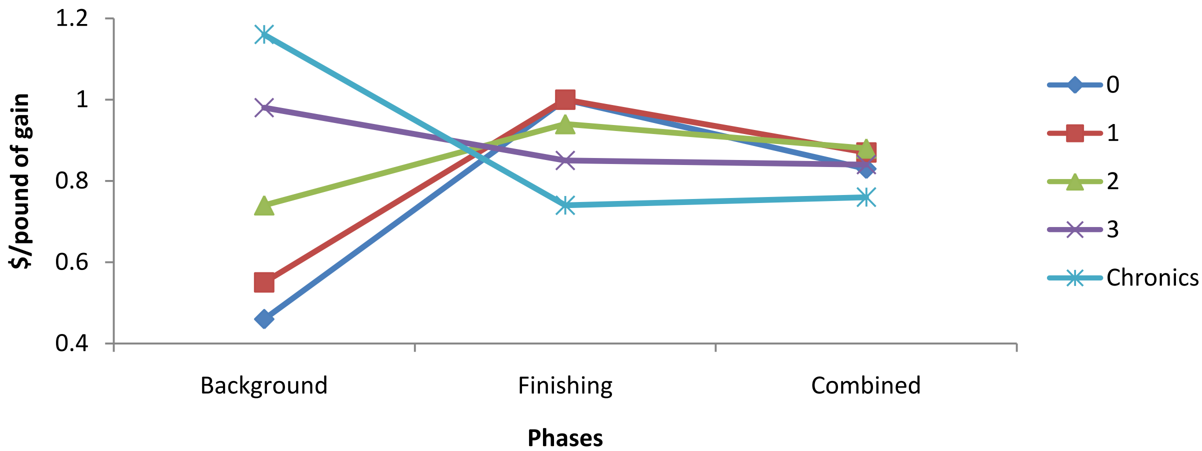

Figure 1. Differences in Cost of Gain ($/lb of gain) by Number of Bovine Respiratory Disease Treatments for the Background, Finishing, and Combined Phases

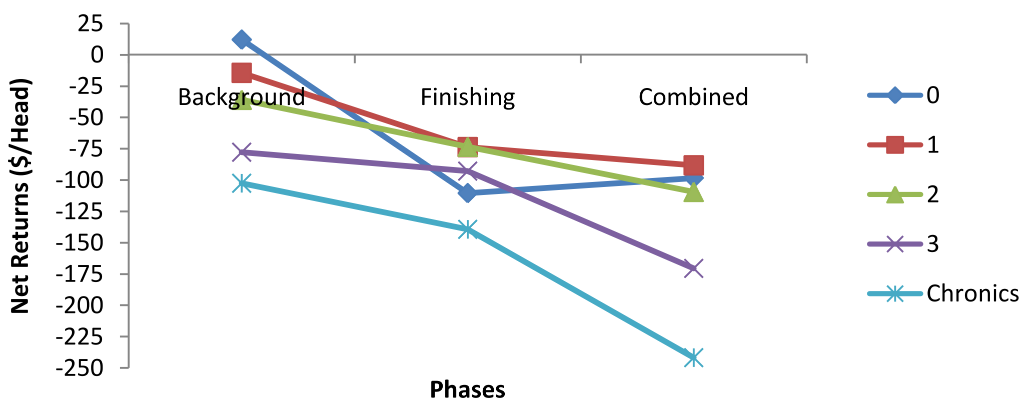

Figure 2. Differences in Net Returns ($/Head) by Number of Bovine Respiratory Disease Treatments for the Background, Finishing, and Combined Phases

Table 1. Summary Statistics for Backgounding phase, Finishing Phase, and Overall

Variable	Description	N	Mean	S.D.	Minimum	Maximum
CATEGORY	# of BRD Treatments	222	1.95	1.67	0.00	4.00
riskgroup	Haptoglobin Risk Group	222	2.23	0.81	1.00	3.00
Kill	Kill Group[a]	189	1.75	0.70	1.00	3.00
IBW	Beginning Weight (lbs)	222	530.39	37.41	413.00	632.50
Ipricecwt	Initial Price ($/cwt)	222	113.39	1.49	110.73	119.50
ip	Placement Cost ($/head)	222	600.87	34.96	493.53	700.37
precadg	ADG-Backgrounding (lbs/day)	222	1.95	1.67	-4.00	5.02
preccog	Background Cost of Gain ($/lb of gain)	222	0.01	6.92	-100.47	7.10
preconv	Background Feed:Gain Conversion	222	3.99	35.15	-474.77	79.13
pcostasfed	Cost of Feed Backgrounding ($/Head)	222	65.19	23.69	4.43	128.74
pdrugs	Backgrounding Drugs ($/head)	222	5.19	0.17	4.84	5.84
rtreatcost	BRD treatment Drugs ($/head)	222	18.20	14.54	0.00	49.31
pnetret	Net Returns-Backgrounding ($/head)	222	-112.35	218.48	-763.33	63.95
avgFO	End Background Start Finishing (lbs)	193	683.44	72.93	475.00	888.50
PD63cwt	Transfer Price ($/cwt)	193	97.26	1.26	94.21	100.96
d63p	Transfer Revenue/Cost ($/head)	193	663.81	62.64	479.55	837.07
fadg	ADG - Finishing (lbs/day)	193	3.19	0.59	-0.29	4.42
fincog	Finishing Cost of Gain ($/lb of gain)	193	0.94	0.24	-0.37	2.19
finconv	Finishing Feed:Gain Conversion	193	8.77	2.29	-3.56	20.39
fdrugs	Finishing Phase Drugs ($/head)	193	2.60	0.00	2.60	2.60
fcostasfed	Cost of Feed finishing ($/head)	193	493.56	65.12	60.73	566.89
fnetret	Net Returns Finishing ($/head)	193	-86.90	136.62	-803.31	201.21
fnetretq	Net Returns Finishing QG ($/head)	192	-88.05	134.35	-803.31	236.76
fnetrety	Net Returns Finishing YG ($/head)	192	-87.74	135.44	-803.31	192.40
FINAL	Final Weight (lbs)	193	1197.11	195.83	0.00	1509.00
gridcwt	Final Price ($/cwt)	189	147.23	7.87	107.50	156.50
pfinal	Ending Revenue ($/head)	189	1095.78	112.42	566.53	1378.39
QGpcwt	Quality Grade Final Price ($/cwt)	188	147.02	7.43	118.04	181.42
qgp	Ending Quality Grade Revenue ($/head)	188	1094.39	112.33	652.06	1482.20
Ygpcwt	Yield Grade Final Price ($/cwt)	188	147.18	7.77	118.04	161.82
ygp	Ending Yield Grade Revenue ($/head)	188	1095.07	109.60	662.07	1389.92
fulladg	Overall ADG (lbs)	222	2.44	1.63	-4.00	4.71
totalcog	Overall Cost of Gain ($/lb of gain)	222	0.15	6.90	-100.47	7.10
totalcon	Overall Feed: Gain Conversion	222	3.91	34.75	-474.77	79.13
netret	Overall Net Returns ($/head)	222	-187.89	229.84	-816.16	146.93
netretqg	Overall Net Returns QG ($/head)	222	-189.20	229.05	-816.16	210.56
netretyg	Overall Net Returns YG ($/head)	222	-188.62	228.71	-816.16	138.12
HCW	Hot Carcass Weight (lbs)	189	743.81	61.92	527.00	922.00
MARBSCORE	Marbling Score	186	457.10	88.76	260.00	730.00
REA	Rib eye area	186	12.12	1.58	8.39	17.83
YG	USDA Yield Grade	185	3.19	0.84	0.67	5.31
USDAQG2	USDA Quality Grade	189	2.32	0.67	1.00	8.00

[a]There were three different kill groups with days on feed of 152, 174, and 189 with the final date determined by live weight and estimated carcass backfat of 0.4 inch using ultrasound.

Table 2. Average Net Returns for Backgrounding, Finishing, and Combined Phases across Haptoglobin Risk Group and Number of Bovine Respiratory Disease Treatments

		Number of Bovine Respiratory Disease Treatments						
Haptoglobin Risk Group	Data	0	1	2	3	Chronics	Dead	Grand Total
	Backgrounding Phase	14.69	-12.05	-44.20	-74.54	-89.05	-677.95	-81.56
	Finishing Phase	-115.23	-68.87	-62.50	-192.88	-5.69		-92.45
1	Combined Phase	-100.54	-80.92	-106.70	-267.42	-94.75	-677.95	-165.29
	Backgrounding Phase	18.09	-10.84	-33.88	-78.49	-117.57	-631.46	-109.30
	Finishing Phase	-107.46	-53.76	-118.32	-45.50	-210.32		-92.86
2	Combined Phase	-89.37	-64.60	-152.20	-124.00	-327.88	-631.46	-189.49
	Backgrounding Phase	3.61	-20.75	-29.89	-80.08	-100.84	-676.36	-130.14
	Finishing Phase	-108.90	-98.56	-39.64	-39.73	-201.57		-80.00
3	Combined Phase	-105.29	-119.31	-69.53	-119.82	-302.41	-676.36	-198.49
Total Average Backgrounding Net Returns		11.78	-15.44	-34.62	-78.92	-105.85	-662.70	-112.35
Total Average Finishing Net Returns		-110.15	-77.60	-64.20	-60.99	-172.57		-86.90
Total Average Combined Net Returns		-98.37	-93.04	-98.82	-139.92	-278.41	-662.70	-187.89

Table 3. Least Squares Means for Production Characteristics by Haptoglobin Risk Group

		Risk Group		
	Description	1	2	3
IBW	Beginning Weight (lbs)	534.65	521.43	527.98
Precadg	ADG-Backgrounding (lbs/day)	1.61	1.66	1.53
Preconv	Background Feed:Gain Conversion	6.99[a]	-6.79[b]	8.27[a]
Rtreatcost	BRD Treatments Drugs ($/head)	22.25	22.28	22.65
Pcostasfed	Cost of Feed Backgrounding ($/Head)	60.29	60.82	57.94
Preccog	Background Cost of Gain ($/lb of gain)	0.60[a]	-1.84[a]	0.81[b]
avgFO	End Background Start Finishing (lbs)	672.44	663.49	656.28
fadg	ADG - Finishing (lbs/day)	3.22	3.08	3.14
finconv	Finishing Feed:Gain Conversion	8.68	8.30	8.27
fcostasfed	Cost of Feed finishing ($/head)	498.70	493.35	478.71
fincog	Finishing Cost of Gain ($/lb of gain)	0.93	0.89	0.89
fulladg	Overall ADG (lbs)	2.19	2.22	2.18
totalcon	Total Feed:Gain Conversion	6.13	-4.66	5.31
totalcog	Overall Cost of Gain ($/lb of gain)	0.61	-1.44	0.54
HCW	HCW (lbs)	744.18	736.45	731.44
Marbscore	MARBSCORE	479.82[a]	450.63[a,b]	433.49[b]
YG	Yield Grade	3.22	3.18	3.10
Pnetret	Net Returns-Backgrounding ($/head)	-147.18	-142.36	-150.72
Fnetret	Net Returns Finishing ($/head)	-89.04	-107.07	-97.68
Netret	Net Returns ($/head)	-221.38	-231.59	-232.12

[a,b] indicate means in the same row with a different superscript letter differ ($P<0.05$)

Table 4. Least Squares Means for Production Characteristics by Number of Bovine Respiratory Disease Treatments

		Number of Treatments					
	Description	0	1	2	3	Chronics	Dead
IBW	Beginning Weight (lbs)	533.50	536.06	524.36	532.25	519.52	522.44
Precadg	ADG-Backgrounding (lbs/day)	3.20^{a}	2.67^{b}	2.35^{b}	1.55^{c}	0.95^{c}	-1.11^{d}
Preconv	Background Feed:Gain Conversion	7.73^{a}	8.12^{a}	8.68^{a}	9.41^{a}	10.62^{a}	-27.62^{b}
Rtreatcost	BRD Treatments Drugs ($/head)	0.27^{a}	9.87^{b}	24.66^{c}	35.52^{d}	35.55^{d}	28.48^{e}
Pcostasfed	Cost of Feed Backgrounding ($/Head)	86.51^{a}	74.80^{b}	65.99^{c}	52.14^{d}	$44.12^{d,e}$	34.54^{e}
Preccog	Background Cost of Gain ($/lb of gain)	0.46^{a}	0.55^{a}	0.74^{a}	0.98^{a}	1.16^{a}	-4.75^{b}
avgFO	End Background Start Finishing (lbs)	734.92^{a}	703.95^{b}	672.22^{c}	629.77^{d}	579.47^{e}	
fadg	ADG - Finishing (lbs/day)	$3.11^{a,b}$	3.20^{a}	3.26^{a}	3.36^{a}	2.78^{b}	
finconv	Finishing Feed:Gain Conversion	9.30^{a}	9.21^{a}	$8.75^{a,b}$	$7.94^{b,c}$	6.89^{c}	
fcostasfed	Cost of Feed Finishing ($/head)	486.18^{a}	$494.20^{a,b}$	484.11^{a}	516.81^{b}	469.97^{a}	
fincog	Finishing Cost of Gain ($/lb of gain)	1.00^{a}	1.00^{a}	$0.94^{a,b}$	$0.85^{b,c}$	0.74^{c}	
fulladg	Overall ADG (lbs)	3.14^{a}	3.06^{a}	3.01^{a}	$2.80^{a,b}$	2.30^{b}	-1.11^{c}
totalcon	Total Feed:Gain Conversion	8.70^{a}	8.84^{a}	8.61^{a}	7.95^{a}	7.09^{a}	-27.62^{b}
totalcog	Overall Cost of Gain ($/lb of gain)	0.83^{a}	0.87^{a}	0.88^{a}	0.84^{a}	0.76^{a}	-4.75^{b}
HCW	HCW (lbs)	756.70^{a}	$743.75^{a,b}$	$733.69^{a,b}$	$747.63^{a,b}$	705.00^{b}	
Marbscore	MARBSCORE	480.43	465.33	444.75	453.56	429.17	
YG	Yield Grade	3.35^{a}	$3.25^{a,b}$	$3.10^{a,b}$	2.94^{b}	$3.19^{a,b}$	
Pnetret	Net Returns-Backgrounding ($/head)	12.13^{a}	-14.55^{b}	-35.99^{c}	-77.71^{d}	-102.49^{e}	-661.92^{f}
Fnetret	Net Returns Finishing ($/head)	-110.53	-73.73	-73.49	-92.71	-139.19	
Netret	Net Returns ($/head)	-98.40^{a}	-88.28^{a}	-109.48^{a}	$-170.41^{a,b}$	-241.68^{b}	-661.92^{c}

^{a,b,c,d,e} indicate means in the same row with a different superscript letter differ ($P<0.05$)

Table 5. Standardized Beta Estimates for Backgrounding Phase Net Returns ($/head)

Variable	Description	Estimate	Standard Error	t Value	P-Value	Standardized Estimate
Intercept	Intercept	-471.315	18.895	-24.94	<.0001	0.000
IBW	Beginning Weight (lbs)	-0.344	0.034	-10.16	<.0001	-0.059
precadg	ADG-Backgrounding (lbs/day)	8.008	1.850	4.33	<.0001	0.061
preconv	Background Feed:Gain Conversion	-0.092	0.038	-2.42	0.0168	-0.015
rtreatcost	BRD Treatments Drugs ($/head)	-1.157	0.344	-3.36	0.0009	-0.077
pcostasfed	Cost of Feed Backgrounding ($/head)	-0.761	0.108	7.03	<.0001	0.083
R1	Haptoglobin Risk Group 1 with respect to Group 3	2.581	3.110	0.83	0.4089	0.005
R2	Haptoglobin Risk Group 2 with respect to Group 3	2.103	2.945	0.71	0.4760	0.004
c0	Zero BRD Treatments with respect to Deads	574.878	10.422	55.16	<.0001	1.131
c1	One BRD Treatments with respect to Deads	573.920	7.734	74.20	<.0001	1.130
c2	Two BRD Treatments with respect to Deads	574.554	6.467	88.85	<.0001	0.949
c3	Three BRD Treatments with respect to Deads	566.340	7.322	77.35	<.0001	0.989
c4	Chronics with respect to Deads	544.518	8.160	66.73	<.0001	0.565

Table 6. Standardized Beta Estimates for Finishing Phase Net Returns ($/head)

Variable	Description	Estimate	Standard Error	t Value	P-Value	Standardized Estimate
Intercept	Intercept	-287.764	122.635	-2.35	0.0201	0.000
avgFO	End Background Start Finishing (lbs)	-0.901	0.109	-8.26	<.0001	-0.623
fadg	ADG-finishing (lbs/day)	9.566	23.579	0.41	0.6855	0.044
finconv	Finishing Feed:Gain Conversion	-3.944	6.676	-0.59	0.5554	-0.064
fcostasfed	Cost of Feed Finishing ($/head)	-0.531	0.186	-2.85	0.0049	-0.177
HCW	Hot Carcass Weight	1.453	0.132	11.01	<.0001	0.870
MARBSCORE	Marbling Score	0.126	0.050	2.53	0.0122	0.109
YG	Yield Grade	-16.882	5.083	-3.32	0.0011	-0.139
R1	Haptoglobin Risk Group 1 with respect to Group 3	1.448	9.873	0.15	0.8836	0.006
R2	Haptoglobin Risk Group 2 with respect to Group 3	-8.225	9.274	-0.89	0.3764	-0.037
c0	Zero BRD Treatments with respect to Chronics	19.610	21.471	0.91	0.3624	0.087
c1	One BRD Treatments with respect to Chronics	32.138	20.639	1.56	0.1213	0.143
c2	Two BRD Treatments with respect to Chronics	15.445	20.724	0.75	0.4571	0.057
c3	Three BRD Treatments with respect to Chronics	14.173	19.924	0.71	0.4778	0.055

Table 7. Standardized Beta Estimates for Total Net Returns ($/head)

Variable	Description	Estimate	Standard Error	t Value	P-Value	Standardized Estimate
Intercept	Intercept	-121.493	125.809	-0.97	0.336	0
IBW	Beginning Weight (lbs)	-0.849	0.139	-6.09	<.0001	-0.294
fulladg	Overall ADG (lbs/day)	-65.854	21.491	-3.06	0.0025	-0.268
totalcon	Total Feed:Gain Conversion	-33.247	7.785	-4.27	<.0001	-0.374
rtreatcost	BRD Treatment Drugs ($/head)	1.654	1.944	0.85	0.3962	0.214
totalcostasfed	Cost of Feed Backgrounding ($/head)	-0.277	0.194	-1.43	0.1560	-0.080
HCW	Hot Carcass Weight	1.363	0.133	10.24	<.0001	0.781
MARBSCORE	Marble Score	0.107	0.049	2.18	0.0303	0.088
YG	Yield Grade	-17.835	5.013	-3.56	0.0005	-0.140
R1	Haptoglobin Risk Group 1 with respect to Group 3	5.637	9.745	0.58	0.5637	0.023
R2	Haptoglobin Risk Group 2 with respect to Group 3	-9.027	9.110	-0.99	0.3231	-0.039
c0	Zero BRD Treatments with respect to Chronics	129.005	73.713	1.75	0.0819	0.545
c1	One BRD Treatments with respect to Chronics	118.625	55.761	2.13	0.0348	0.504
c2	Two BRD Treatments with respect to Chronics	65.801	31.006	2.12	0.0353	0.232
c3	Three BRD Treatments with respect to Chronics	27.689	19.465	1.42	0.1567	0.102