final report

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B.FLT.0246 Impact of subclinical bovine respiratory disease

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Abstract

Bovine respiratory disease (BRD) is the most prevalent and costly disease of Australian feedlot cattle. Research conducted in the United States reports that cattle with lung abnormalities have decreased carcase weight and fatness (including marbling). However, up to 50 % of cattle with lung abnormalities at slaughter exhibit no clinical signs of BRD during the feeding period. No peer-reviewed data is available on the subclinical incidence of BRD of Australian feedlot cattle.

This study collected records on 1274 cattle inducted to a commercial feedlot during 2017. The cattle were monitored during the feeding period and all production and animal health data were collected in both the live animal and at the carcase level.

A key result of the study is that BRD treatment in the feedlot did not have a significant association with the disease classification in the carcase or on carcass traits. This may be due to a number of reasons, such as the treated animals fully recovering, animals having pre-existing lung damage upon entry to the feedlot, or some animals maintaining a sub clinical status during the feeding period and so not receiving a treatment. It may also be plausible that there was a poor accuracy of BRD diagnosis which would lead to a poor association between treatment records and gross pathology. Induction weight had a positive effect on disease outcome. The trend was that heavier induction weights resulted in less disease being recorded at the carcase level. There was a trend that pre-vaccination of cattle prior to feedlot entry reduced disease outcome in the carcase but it was not significant.

Hot Standard Carcase Weight (HSCW), Average Daily Gain (ADG) and Carcase Fat Depth (P8) were all significantly affected by Breed and Induction weight and combined disease classification in the carcase. HSCW was significantly lower in cattle that had a severe disease classification compared to a normal or moderate classification.

Executive summary

Bovine Respiratory Disease is a major disease in feedlot cattle worldwide. There have been numerous studies that have attempted to evaluate the cost of the disease to the industry but many have been limited to only consider the cost to the feedlot or on a gross carcase value. No peer reviewed data is available on the subclinical incidence of BRD to Australian feedlots.

This study collected records on 1274 cattle inducted to a commercial feedlot during Autumn and Spring in 2017. The cattle were monitored during the feeding period and all production and animal health data were collected. At slaughter the carcases were assessed for gross pathology to determine the occurrence and severity of disease. A combined lung and pleurisy classification system was established which gives a severity classification based on post-mortem pathology. All carcase data was collected on the animals processed.

A key result of the study is that BRD treatment in the feedlot did not have a significant association with the disease severity classification in the carcase. This may be due to a number of reasons, such as the treated animals fully recovering, poor diagnosis by pen riders of animals with BRD, animals having pre-existing lung damage upon entry to the feedlot or some animals maintaining a sub clinical status during the feeding period and so not receiving a treatment.

Induction weight had a positive effect on disease outcome. The trend was that heavier induction weights resulted in less disease being recorded at the carcase level. There was a trend that pre-vaccination of cattle prior to feedlot entry reduced disease severity classification in the carcase but it was not significant.

Hot Standard Carcase Weight (HSCW), Average Daily Gain (ADG) and Carcase Fat Depth (p8) were all significantly affected by Breed and Induction weight and disease severity classification. HSCW was significantly lower in cattle that had a severe classification compared to a normal or moderate classification.

The season of feedlot entry had an effect on ADG and Carcase Fat Depth (P8) and Rib Fat. The favourable conditions during the Autumn entry feeding period may account for the difference with the Spring entry cohort being fed during hot months of the year.

Marbling and meat colour were not significantly affected by disease severity classification.

The Industry will benefit from this work by having a clearly understanding of the interactions between BRD treatments and gross pathology at the carcase level and how the disease outcome impacts carcase traits.

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1 Background

Bovine respiratory disease (BRD) is the most prevalent and costly disease of Australian feedlot cattle. The disease results in lung damage of feedlot cattle with adhesions, tissue consolidation and abscesses commonly evident at slaughter. Research conducted in the United States reports that cattle with lung abnormalities have decreased carcase weight and fatness (including marbling). Additionally, up to 50 % of cattle with lung abnormalities at slaughter exhibit no clinical signs of BRD during the feeding period. These undetected animals are termed 'sub-clinical'.

No peer-reviewed data is available on the subclinical incidence of BRD of Australian feedlot cattle. This project will generate data to quantify the economic impact of Bovine Respiratory Disease (BRD) to Australian feedlots via an analysis of feedlot induction records, BRD treatment records and lung abnormalities at slaughter.

This project compliments other research efforts currently occurring within MLA to improve peri-mortem disease information of individual animals back to producers.

2 Project objectives

(1) Determine the effect of number of BRD antimicrobial treatments and lung abnormalities at slaughter on feedlot performance and carcase characteristics of feedlot cattle

3 Methodology

3.1 Prospective cohort study

A total of 1650 head of steers were inducted into a southern Australian feedlot; the first cohorts were inducted during April & May 2017 and were between 250 and 380 kgs at induction. The fifth and sixth cohorts inducted during September and October were between 380 and 500kg at induction. Most of these cattle were Angus with the remainder being Angus cross, Shorthorn and Hereford. The cattle arrived at the feedlot the night prior to induction and had free access to clean water. The 6 cohorts were filled over a 14-day period. The animals included in each pen resulted from the commercial purchasing habits by the feedlot.

The cattle induction process involved scanning the individual animal's NLIS RFID tag, applying a lot tag, individual animal identification, treatment with Bovilis MH + IBR (Coopers Animal Health), Rhinoguard (Zoetis Animal health), and backline Benzidamole drench. All cattle were implanted with a commercially available HGP at induction. Individual animal weights were collected using a Warwick cattle hydraulic squeeze chute which2s was calibrated prior to inductions starting.

Once induction was completed the cattle were relocated to a dirt floor pens which were 80m long and 50m deep (13.3m^2) and a total bunk length of 73.5m (24.5cm/head). All pens have slatted corrugated shade, 4m high and 8m in width. All pens had a similar manure depth and were cleaned during the trial. Each pen has 2 troughs per pen which were located along the side fences of the pen. These troughs were cleaned twice weekly during the trial.

3.2 Morbidity Management

Trial pens had pen riders enter the pen between 07:00h & 08:30h each morning. A team of 2 pens riders rode the pens daily, at least one of them was a senior pen rider. Cattle were monitored for clinical symptoms of BRD. The main clinical symptoms used by pen riders to identify clinically sick animals included general listlessness, lethargy, dull and lack of purpose. More severe cases of BRD exhibited profound depression, low head carriage, slow moving, sleepy/dull eyes and markedly reduced pray animal awareness.

Animal displaying clinical symptoms of BRD which were under 80 DoF were treated with Draxxin (Zoetis, Tulathromycin, 100mg/ML, @ 1mL/40kg body weight) as a primary treatment. If animals were still exhibiting clinical symptoms after 5 days they were provided with a second treatment of Engemycin 100 (Coopers Animal Health, Oxytetracycline 100mg/mL @ 1mL/10kg body weight). Only severely ill animals were not returned to their home pen after treatment. Animals which were pulled a third time from their pen were not treated but placed in a chronic pen and sold separately to the main cohort of animals. Animals displaying clinical symptoms of BRD after 80 DoF were only treated with Engemycin 100.

The management of BRD in the feedlot also included an in feed antimicrobial, which was micro-granulated chlorotetracyline hydrocholoride. This was fed at 0.4% of the ration weight for the first 14 days on feed.

The two other main conditions which animals were treated for during the trial were lameness and bullers. Lame cattle were treated and returned to their home pen, and if the first treatment failed they were removed and retreated. If the retreatment failed, the animals were removed and slaughtered as a chronic (reject animal). Bullers were removed from the pen and moved to a pen containing only bullers, and slaughtered in buller lots.

Daily treatment details were collected manually by an experimental monitor and with the feedlots electronic health management system. The data collected on all animals through the feedlot hospital system were treatment type, volume of drug administered, rectal temperature, individual animal ID and pull reason. Data was aligned from each source to ensure the accuracy of information collected.

3.3 Mortality Management

All cattle that died during the trial had post mortems conducted by a senior stock hand on the feedlot. All mortalities had photos taken and provided to the consulting veterinarian. The information recorded on all deaths, was place of death, post mortem findings, home pen, lot, individual animal's ID and date.

3.4 Feed & Bunk Management

Cattle were transitioned from the starter ration to the finisher ration over a 21 d period. The first 3 cohorts of animals inducted were transitioned to the finisher diet using 3 transition rations (starter, intermediate 1, intermediate 2). The last three cohorts were transitioned to the finisher diet using a titration feeding using 2 rations. Once cattle were on the finisher ration, cattle were fed twice daily.

Rations were delivered in feed trucks with Rotomix 920 mixer boxes (Rotomix, Kansas). The two feed trucks had their scale plates calibrated prior to starting the trial and had twice weekly weight variance checks completed. The time, date and weight of feed delivered to each pen was recorded in the feedlot management system with delivery weight delivered by email every night. This information was stored in an excel spreadsheet until the end of the trial.

Ration samples from a ration 4 were taken daily to obtain the ration dry matter. A minimum of 2 pens were sampled daily and 2 samples of 100g were placed in an oven at 95°C for a minimum of 16 hours.

A ration sample was collected weekly from a minimum of 3 pens on ration 4 for analysis. The ration samples were frozen and combined every 4 weeks for analysed at Symbio Labs (52 Brandl St Eight Mile Plains, QLD, 4113). The analysis returned results for Dry Matter, Protein, NDF, Fat, Fibre, Ash, Calcium & Phosphorus.

3.5 Live Animal Management

3.5.1 60 Day weight

The 60-day weight was collected when animals were between 50 and 65 days due to the induction occurring over 14 days per lot. The date which the weights were taken from each cohort and the range in days on feed are displayed in Table 1.

Table 1: Date and number of days on feed which the 50-day weights were collected.

Cohort	Date weight collected	Minimum DoF	Maximum DoF
1	21/6/2017	54	55
2	28/6/2017	57	61
3	3/7/2017	59	61
4	17/7/2017	53	60
5	17/11/2017	56	65
6	28/11/2017	53	55

The weight was obtained on the same scales as feedlot induction. The cattle were removed from their pen prior to their morning feed and placed in a dry yard until the weights were collected. The weights were collected within the 5 hours and returned to their home pens once all cattle had been weighed.

3.5.2 Mob based exist weights

Two days before cattle were scheduled for slaughter they were relocated from their home pen to load out yards. This move was conducted prior to the morning feeding. On arrival at the load out yards cattle were weighed into groups for transit. Once the cattle were processed for load out they were placed in a trucking yard and fed prior to exiting the feedlot the following day.

The weight management requirements of trucks allow no more than 35 tonnes, the trucking weight of animals was aligned with the animal's RFID during the loadout process. The cattle were trucked in groups of between 46 and 52 head.

3.5.3 Dead weight

The collection of a live weight per slaughter was unavailable for commercial reasons. However, the processing facility used for slaughter allows a dead weight to be recorded. The scale plates are placed at the 1st station post slaughter. The dead weight of the animal is the live animals weight minus blood, this weight was used to calculate the ADG to slaughter.

Variaton in slaughter days on feed for each breed within cohort is detailed below in Table 2.

Table 2: Variation in number DoF for cattle slaughtered by induction cohort

Cohort	**Angus Cattle**		**Other Breeds**	
	Minimum DoF	Max DoF	Minimum DoF	Max DoF
1	192	193	201	202
2	208	213	203	208
3	210	215	212	217
4	200	207	203	210
5	153	161	143	143
6	146	150	152	166

3.6 Slaughter

After cattle had been weighed for trucking they were placed in a load out yard and fed. They were trucked the following day and processed the day after that. All animals except chronics and bullers were slaughter in the date ranges listed in Table 3.

Table 3: Cattle slaughter dates

Cohort	**Start Slaughter Date**	**Finish Slaughter Date**	**Total Head slaughtered**
1	6/11/2017	15/11/2017	275
2	22/11/2017	27/11/2017	248
3	4/12/2017	6/12/2017	269
4	11/12/2017	14/12/2017	274
5	12/2/2018	22/2/2018	283
6	26/2/2018	19/2/2018	286

The total number of cattle slaughtered from the original induction cohorts was 1635. These animals were all slaughtered as a mid-fed grain fed animals. A total of 11 animals were classified as chronically infected or bullers and were slaughtered independent of the cohort they were allocated to. In addition, there were 4 deaths during the project. Lung pathology data was only collected on 1274 animals.

3.7 Carcase data

In addition to the lung scoring, standard carcase data was collected on all carcases processed. This included a dead weight, hot standard carcase weight, dentition, P8 (rump) fat depth, dentition and if the carcase had any bruises was all collected on the carcase prior to exiting the slaughter floor. Any carcases that had extensive trimming were noted on the lung scoring data collection sheets.

After carcases had been chilled for between 18 and 24 hours they were removed from the chiller and graded in accordance with plant specifications. After splitting the carcases, they were graded using MSA protocols by plant-based graders with the following scores data recorded: AusMeat and MSA marbling, pH, meat colour, fat colour, hump height, ossification, eye muscle area and rib fat depth.

3.8 Gross pathology scoring post mortem

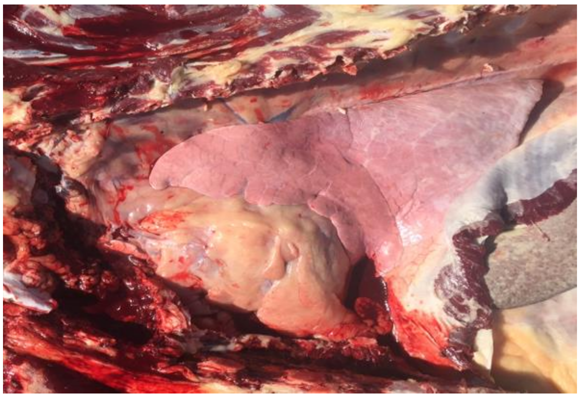
Assessment of animal’s lung pathology during slaughter was conducted to understand carcase variation through sub-clinical and clinical disease. The lung scoring method used was modified from Rezac et al. (2014) to increase the level of granularity from the data collected. All animals slaughtered had a score collected on the lungs and thorax to assess the different types of infection associated with BRD. Both anatomical structures were classed from 0 to 3 for the severity of the infection. The Lung scoring method used in shown in Figure 1 and thoracic cavity scoring is shown in Figure 2.

Gross pathology scoring was conducted by visual inspection of two people, one located at the evisceration table and the second at the offal chain. All personal involved had completed a minimum of 3 years completed of an animal’s science bachelor's degree. Training was conducted by a senior feedlot veterinarian prior to the commencement of the trial cattle slaughtered commencing.

The classification of carcasses as Normal, Moderate and Severe was completed using the matrix below.

Lung Consolidation	*Pleurisy Score*	**0**	**1**	**2**	**3**
0	**0**	N	N	M	S
1-10%	**1**	N	M	M	S
11-49%	**2**	M	M	S	S
>50%	**3**	S	S	S	S
No Score		M	M	M	S

0.



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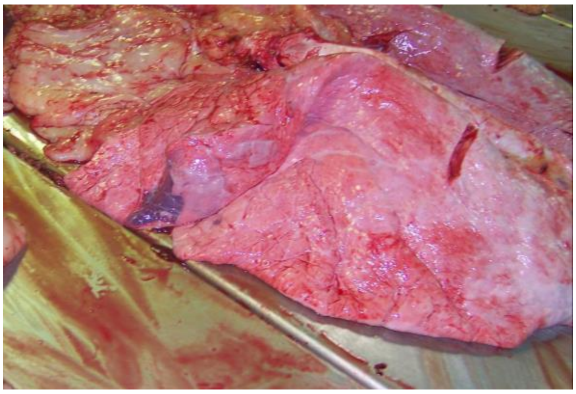

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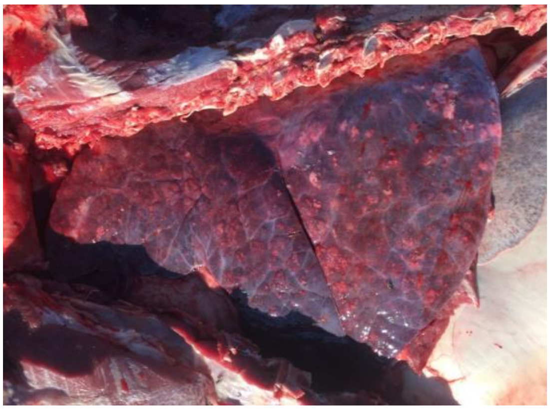


Figure 1: Lung Pathology Scoring, 0, normal lung; 1, < 10% consolidation; 2, 10% to 50% consolidation; and, 3, >50% consolidation.

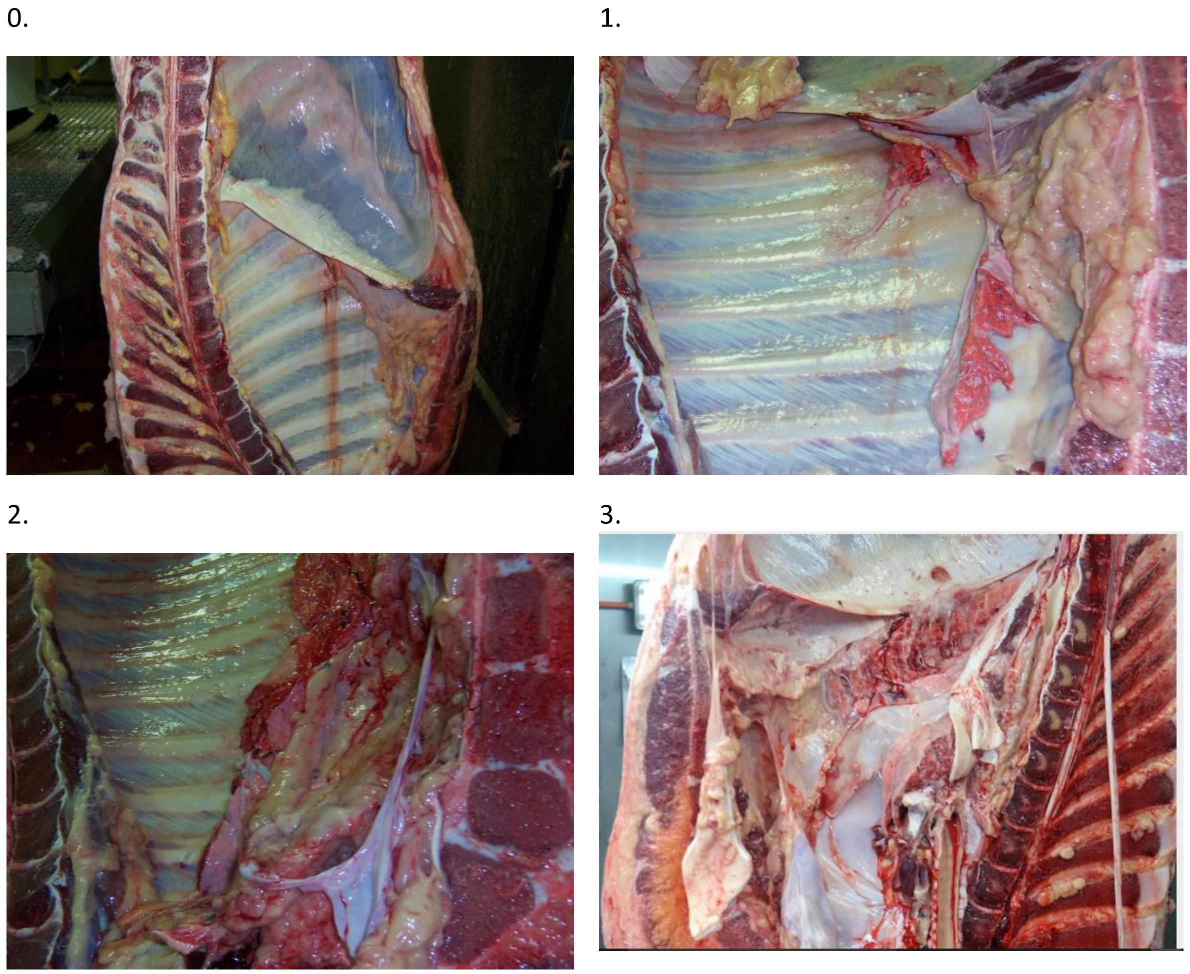


Figure 2: Pleurisy scores ranged from 0-3. Score 0 is no pleurisy, score 1 is pleuritic tags between lung lobes, or on the lung surface with no adhesion on the pleura of the thorax, a score 2 was pleuritic lesions with localized adhesion to the thoracic wall, and a score 3 was severe pleuritic adhesions with the chest requiring "Stripping".

3.9 Statistical Analysis

Descriptive analysis was conducted using Microsoft Excel (2017) for feedlot performance and carcass characteristics. Statistical analysis to identify associations between BRD related variables (e.g. treatment and lung scoring) with feedlot performance and carcass characteristics was conducted using Genstat (VSN International, Hemel Hempstead, UK. 2011). Univariable and multivariable generalised linear mixed models were used for continuous dependent variables and ordinal logistic regression analysis was used for ordinal dependent variables.

The outcome (dependent) variables tested were: Hot Standard Carcase Weight (HSCW), Average Daily Gain (Induction to Slaughter, kg), Carcase fat depth (p8), marble score, meat colour, MSA marbling, pH, rib fat, ossification and disease outcome (combined pleurisy and lung score).

The explanatory variables considered were induction weight, pre-vaccination (prior to feedlot entry), animal breed, season of feedlot entry, BRD treatments at feedlot and days on feed (DoF). The disease outcome (combined pleurisy and lung score) was also used as an explanatory variable for the analysis in relation to Average Daily Gain and carcass characteristics.

To better understand the potential association of BRD treatment and the disease outcomes on the outputs of interest, two different analyses were performed, each only including one of the two explanatory variables. However, given both variables were considered likely to impact on the outputs of interest and also interact with each other, the final models reported here, are those where both, the BRD treatments and the disease outcomes, are considered in the same model.

For all analyses, producer was incorporated into the models as a random effect.

For all statistical analyses, initially, univariable analysis was conducted to investigate associations of each explanatory variable with the dependent variable. Those explanatory variables associated with the outcome with a p-value of < 0.2 were considered for the multivariable analysis. Collinearity between these explanatory variables was investigated and when two variables were found to be highly collinear only one of the variables of the pair was considered for the multivariable analyses. Backward selection procedure was used for variable selection for the multivariable model, with variables retained in the final model if they reported a *P*-value <0.05.

4 Results

4.1 BRD effect on live animal performance and carcase quality

4.1.1 Descriptive statistics.

INDUCTION WEIGHT	MEAN	SE	MAX	MIN	N
NORMAL	373	1.7	499	243	1,274
MODERATE	344	3.2	498	254	340
SEVERE	305	8.7	408	257	21
60 DAY WEIGHT					
NORMAL	492	2.7	679	334	1,274
MODERATE	456	4.7	655	359	340
SEVERE	398	10.9	522	343	21
SLAUGHTER DEAD WEIGHT					
NORMAL	689	3.9	873	505	1,274
MODERATE	672	7.3	815	533	340
SEVERE	625	12.7	737	506	21
HSCW					
NORMAL	399	0.9	517	273	1,274
MODERATE	390	1.7	484	303	340
SEVERE	359	7.8	419	269	21
P8 FAT DEPTH					
NORMAL	20	0.2	47	6	1,274
MODERATE	20	0.3	41	7	340
SEVERE	20	1.3	29	7	21

RIB FAT				
NORMAL	15	34	7	1,274
MODERATE	15	26	8	340
SEVERE	14	22	11	21
OSSIFICATION				
NORMAL	179	230	160	1,274
MODERATE	177	230	160	340
SEVERE	175	200	170	21
MSA MARBLE SCORE				
NORMAL	413	770	240	1,274
MODERATE	417	660	260	340
SEVERE	419	670	170	21
PH				
NORMAL	5.56	5.63	5.51	1,274
MODERATE	5.56	5.64	5.52	340
SEVERE	5.59	5.59	5.54	21
EYE MUSCLE AREA				
NORMAL	85.5	106	70	1,274
MODERATE	85.6	106	70	340
SEVERE	84.3	96	70	21

ADG 0 TO 60 DAYS	**MEAN**	**SE**	**MAX**	**MIN**	**N**
NORMAL	2.05	0.01	3.91	0.11	1,274
MODERATE	1.97	0.03	3.31	0.60	340
SEVERE	1.58	0.11	2.34	0.60	21
ADG 60DAYS TO SLAUGHTER					
NORMAL	1.54	0.01	2.69	0.22	1,274
MODERATE	1.57	0.02	2.18	0.80	340
SEVERE	1.55	0.06	1.98	1.03	21
ADG INDUCTION TO SLAUGHTER					
NORMAL	1.70	0.01	2.44	0.99	1,274
MODERATE	1.69	0.02	2.26	0.92	340
SEVERE	1.56	0.06	1.93	0.95	21

Tables 4.1 to 4.9 provide a summary of the descriptive analysis of the feedlot performance and the carcass characteristics, according to the BRD treatment and disease outcomes.

Table 4.1: Number of animals classified by BRD Lung Score at slaughter according to live animal BRD treatment at the feedlot

	Lung Score				
	0	1	2	3	Missed
1 Treatment	227	267	20	0	0
2 Treatments	120	91	5	1	11
No Treatments	373	485	33	2	0

Table 4.2: Number of animals classified by BRD Pleurisy score at slaughter according to live animal BRD treatment at the feedlot

	Pleurisy Score				
	0	1	2	3	Missed
1 Treatment	365	134	11	8	0
2 Treatments	157	52	9	1	11
No Treatments	576	286	25	10	0

Table 4.3: Number of animals classified by BRD Combined lung and pleurisy classification at slaughter according to live animal BRD treatment at the feedlot

	Combined Score		
	Normal	Moderate	Severe
1 Treatment	401	110	7
2 Treatments	174	40	5
No Treatments	699	190	9

Table 4.4: Distribution of AUS-Meat marble scores according to live animal BRD treatment at the feedlot

	Live Animal BRD Treatments		
Marble Score	1 Treatment	2 Treatments	No Treatments
0	0%	0%	0%
1	9%	16%	12%
2	60%	50%	56%
3	23%	27%	24%
4	6%	4%	6%
5	2%	1%	2%
6	1%	0%	0%
7	0%	0%	0%
No Data	0%	2%	0%

Table 4.5: Distribution of AUS-Meat marble scores according to combined lung & pleurisy severity classification

Marble Score	Combined Lung & Pleurisy classification		
	Normal	Moderate	Severe
0	0%	0%	0%
1	11%	11%	17%
2	57%	55%	57%
3	24%	24%	14%
4	6%	8%	6%
5	2%	2%	6%
6	0%	0%	0%
7	0%	0%	0%
No Data	0%	0%	0%

Table 4.6: Distribution of meat colour scores according to live animal BRD treatment at the feedlot

Meat Colour	Treatments		
	1 Treatment	2 Treatments	No Treatments
1B	1%	2%	2%
1C	51%	46%	49%
2	36%	37%	37%
3	11%	14%	12%
4	0%	0%	0%
5	0%	0%	0%

Table 4.7: Distribution of meat colour scores according to combined lung & pleurisy classification

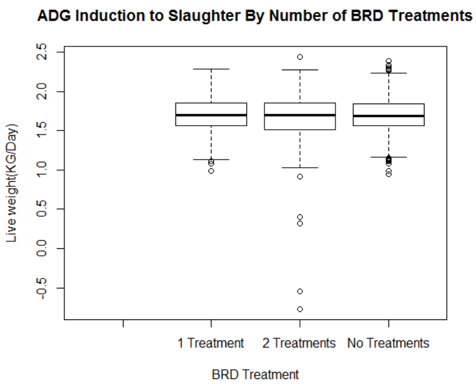
Meat Colour	Combined Lung & Pleurisy Classification		
	Normal	Moderate	Severe
1B	2%	3%	11%
1C	45%	53%	43%
2	41%	34%	34%
3	12%	10%	11%
4	0%	0%	0%
5	0%	0%	0%

Table 4.8: A cross-tab between BRD pre-vaccination and live animal BRD treatment at the feedlot

	Live Animal BRD Treatments		
Pre-Vaccination	1 Treatment	2 Treatments	No Treatments
Yes	83	28	176
No	435	205	722
Yes	29%	10%	61%
No	32%	15%	53%

Table 4.9: A cross-tab between BRD pre-vaccination and the combined lung & pleurisy classification

	Combined Score		
Pre-Vaccination	Normal	Moderate	Severe
Yes	257	27	1
No	1017	313	20
Yes	90%	9%	0%
No	75%	23%	1%



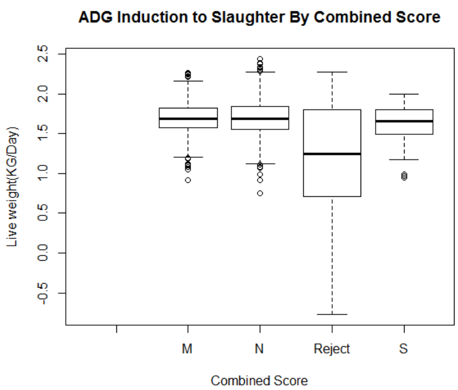


Figure 4.10 Average daily gain (kg) from Induction to Slaughter compared to number of BRD treatments and combined (lung & pleurisy) classification.

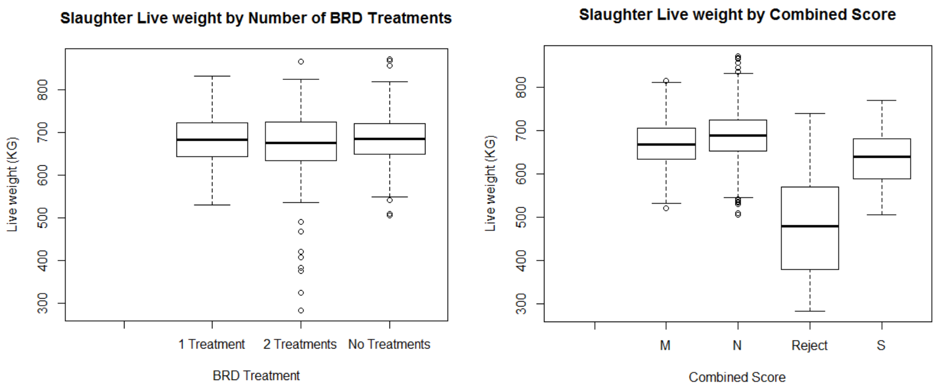


Figure 4.11 Slaughter Liveweight (kg) compared to number of BRD treatments and combined (lung & pleurisy) classification.

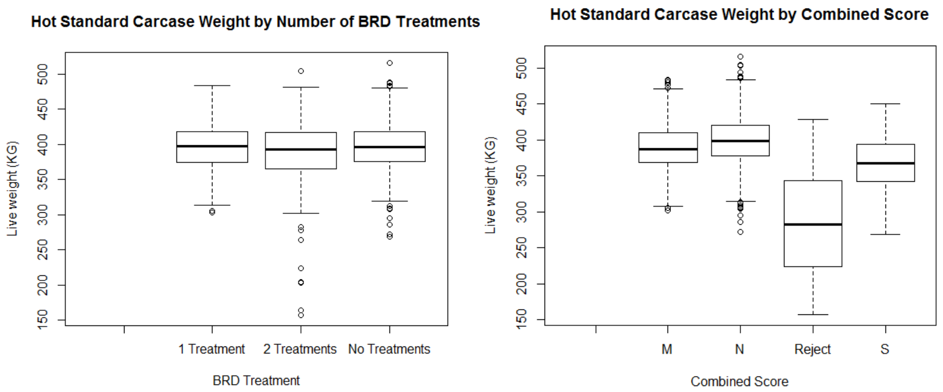


Figure 4.12: Hot Standard Carcase Weight (kg) compared to number of BRD treatments and combined (lung & pleurisy) classification.

4.1.2 Statistical analysis

The final multivariable model for the Hot Standard Carcase weight (Table 4.10) indicates that this output is significantly affected by the animal breed ($P = 0.009$), induction weight ($P < 0.001$), the pre-vaccination status of the animals ($P < 0.001$) and the disease combined classification ($P < 0.001$). As expected, Angus animals had a heavier hot carcass weight than shorthorn animals and the hot carcass weight is positively associated with the induction weight. In relation to the BRD combined classification, animals with a severe and reject classification have a significantly lighter hot carcass weight than animals with a normal or moderate BRD combined classification. In addition, the producer is also significantly associated with the Hot Standard Carcase weight.

Table 4.10. Final multivariable model investigating the impact of BRD on the Hot Standard Carcase Weight

	Hot Standard Carcase Weight			
	Hot Standard Carcass Weight	Parameter estimate	S.E	p-value
Breed			8.36	0.0009
Angus	337.1	0		
Angus Cross	339.6	2.421		
Shorthorn	325.8	-11.287		
Shorthorn Cross	311.3	-25.864		
Induction weight	.	0.516	0.02	<0.001
BRD Pre-Vaccination		0	3.55	<0.001
No	355.5	0		
Yes	301.4	-54.07		
BRD Combined Disease outcome			6.12	< 0.001
Moderate	371.7	0		
Normal	373.9	2.20		
Reject	215.7	-155.94		
Severe	352.6	-19.10		

Table 4.11 shows the final multivariable model in relation to the ADG from induction to slaughter. As the model indicated the average daily gain is greater in Angus animals than Shorthorn (P = 0.002) and it increases with the induction weight (p < 0.001). Similarly, than for carcase weight the average daily gain is also affected by the BRD disease outcome, with those animals classified with a severe or reject having a smaller average daily gain than animals classified as normal or moderate (P < 0.001). The season of the induction was also significantly associated with the ADG, with animals inducted in Autumn having a greater ADG than those inducted in Spring (P < 0.001).

Table 4.11. Final multivariable model investigating the impact of BRD on the Average Daily Gain (Induction to slaughter)

	Average Daily Gain Induction to Slaughter			
	Average Daily Gain	Parameter estimate	S.E	p-value
Breed			0.082	0.002
Angus	1.409	0		
Angus Cross	1.471	0.062		
Shorthorn	1.338	-0.071		
Shorthorn Cross	1.446	0.037		
Induction weight	.	0.0008	0.0002	< 0.001
Season			0.028	<0.001
Spring	1.367	0		
Autumn	1.465	0.097		
BRD Combined Disease outcome			0.053	< 0.001
Moderate	1.684	0		
Normal	1.697	0.014		
Reject	0.740	-0.94		
Severe	1.543	-0.14		

In relation to carcase fat depth (Table 4.12), similar results than those for ADG and carcase weight are observed, with breed, induction weight, season, BRD combined disease classification and producer being significantly associated with this carcase characteristic. The associations between the explanatory variables with the rib fat were also investigated, and analysis suggested a significant association with season (P = 0.036) and BRD combined disease classification (P = 0.025) (Table 4.13). Animals inducted in Autumn had a greater rib fat mean (14.75; s.d. 4.99) than those inducted in Spring (14.17; s.d. 5.0). Only differences between animals classified rejects as BRD disease classification were found to be significantly different to the rest of the animals.

Table 4.12. Final Multivariable model investigating the impact of BRD on carcase fat depth (P8).

Explanatory variables	Carcase fat depth			
	Carcase fat depth (mean)	Parameter estimate	S.E	p-value
Breed			1.724	0.002
Angus	16.41	0		
Angus Cross	17.38	0.966		
Shorthorn	14.54	-1.876		
Shorthorn Cross	20.45	4.037		
Induction weight	.	0.0195	0.0055	< 0.001
Season			0.711	<0.001
Spring	15.30	0		
Autumn	19.09	3.792		
BRD Combined Disease outcome			1.436	< 0.001
Moderate	20.86	0		
Normal	21.08	0.223		
Reject	6.38	-14.49		
Severe	20.45	-0.41		

Table 4.13. Final Multivariable model investigating the impact of BRD on rib fat.

Explanatory variables	Rib fat			
	Rib fat (mean)	Parameter estimate	S.E	p-value
BRD Combined Disease outcome				0.025
Moderate		0	.	
Normal		-0.413	0.311	
Reject		-4.92	1.69	
Severe		-0.21	1.13	
Season				0.036
Spring	14.17	0	0.26	
Autumn	14.75	0.56		

Table 4.14. Final multivariable model investigating the impact of BRD on AUS-Meat marble score

Explanatory variables	Marble Score			
	Marble score (mean, 1 to 5)	Parameter estimate	S.E	p-value
Breed				<0.001
Angus	2.35	0	.	
Angus Cross	2.33	-0.100	0.175	
Shorthorn	1.96	-0.976	0.153	
Shorthorn Cross*	3.00	1.775	0.751	
Days on Feed		0.0068	0.001	<0.001

**6 observations only*

For the marble score analysis, prior to the statistical analysis some of the scores were combined to allow sufficient observations for each category (0 and 1; and, 5 and 6). Thus, the final marble scores used were 1 to 5. Table 4.14 shows the outputs of the ordinal multivariable analysis, which indicate that there was no effect of the BRD treatments or BRD combined scores on the marble score, with only breed and days on feed being significantly associated with this output. However, analysis in relation to MSA marbling identified a significant association (P = 0.007) with the BRD combined disease score, with no other variables found to be significant (Table 4.15). Although a significant difference was found, the difference was between those animals classified as reject (MSA mean 256) and the rest of the animals (MSA means Normal = 407; Moderate = 409; Severe = 441). It is important to consider that a very small cohort of animals were classified as reject (n = 9).

The next carcase characteristic investigated was meat colour. Similar to marble score, prior to the statistical analysis, categories 1B and 1C were combined and analysis was done with three categories (there were no observations for meat colour 4 and 5). No significant differences were observed on meat colour due to BRD factors, with only season being significant (P < 0.001), with animals inducted in Spring being more likely to have higher meat colour scores than those inducted in Autumn. In relation to ph, a significant association (P < 0.001) was found with the BRD combined disease score, with the difference being between animals classified as reject and the rest of the animals (Table 4.15).

Another carcase characteristic investigated was ossification. According to the analysis conducted, the only significant association (P < 0.001) observed was between animals classified reject as BRD combined disease classification and the rest of the animals (Table 4.15). The last carcase characteristic investigated was the eye muscle area (EMA). Analysis indicate that is a significant difference on the EMA and the days on feed and the BRD combine disease classification (Table 4.17). There is a positive relationship between EMA and days on feed (P=0.002) and carcasses classified as reject had a significant lower EMA than the other carcasses (P<0.001).

Table 4.15. Univariable associations between BRD combined disease classification and carcass MSA marbling, ph and ossification

Explanatory variables	MSA marbling			
	MSA marbling (mean)	Parameter estimate	S.E	p-value
BRD Combined Disease outcome				0.007
Moderate	411.7	0	.	
Normal	408.2	-1.64	8.44	
Reject	255.0	-53.1	46.4	
Severe	442.1	31.8	30.9	
	Ph			
BRD Combined Disease outcome				<0.001
Moderate	5.26	0	.	
Normal	5.22	-0.04	0.08	
Reject	3.10	-2.17	0.45	
Severe	5.56	0.30	0.30	
	Ossification			
BRD Combined Disease outcome				< 0.001
Moderate	166.1	0	.	
Normal	164.8	1.23	2.62	
Reject	98.90	-65.9	14.3	
Severe	174.3	9.46	9.38	

We also investigated the factors associated with the BRD disease outcome and the final multivariable analysis indicate that BRD treatment is not associated with the BRD Combined disease classification of the carcase. For this analysis, given the low number of observations of severe and reject classifications, data was transformed into a binary outcome (normal, ≥ moderate) and logistic regression analysis was used. The only variable significantly associated with BRD disease outcome was induction weight (P<0.001), with producer being also significant as a random effect (Table 4.16). The likelihood of severe disease outcomes is reduced by increasing induction weights. With the current dataset, there is only a trend on the association of pre-vaccination with disease outcome (P = 0.056), with those animals vaccinated having a lower likelihood of severe disease than those non-vaccinated.

Table 4.16. Final multivariable model investigating the impact of a set of explanatory variables on the BRD disease classification

Explanatory variables	BRD combined score		
	Parameter estimate	S.E	p-value
Induction weight	-1.228	0.095	<0.001
Pre-vaccination			0.056
No	0	.	
Yes	-0.48	0.249	

Table 4.17. Final multivariable model investigating the impact of a set of explanatory variables on the carcass eye muscle area

Explanatory variables	Eye Muscle Area			
	Eye Muscle Area (mean)	Parameter estimate	S.E	p-value
BRD Combined Disease outcome				<0.001
Moderate	87.1	0	.	
Normal	87.1	0.182	0.31	
Reject	63.3	-24.46	1.55	
Severe	87.2	0.03	1.13	
Days on Feed		0.0144	0.005	0.002

5 Discussion

5.1 Bovine Respiratory Disease effect of carcass quality and live animal performance.

In this study BRD was classified by both live animal (number of treatments) and gross pathology (lung consolidation and pleurisy scoring of the carcase). No significant association between treatment in the live animal and combined disease classification in the carcase was observed. The treatment of animals for BRD in the feedlot was also not a significant explanatory variable for carcass traits. While there is no way to determine causality of this result there are many plausible explanations. Firstly, it is likely that some animals that are treated fully recover and so do not show signs of lung damage at slaughter. This would indicate that if all animals were treated successfully then there is a chance that the effects of BRD on carcase quality could be greatly reduced. A second explanation is that some animals have lung and pleurisy damage prior to feedlot entry, or maintain a subclinical status of disease during the feeding period. Another reason this study didn't find an association with treatment and carcass traits is that feedlot staff may have a low accuracy of BRD diagnosis when pulling cattle from the pens.

The source of cattle (producer) and induction weight were the only variables to have a significant effect on disease outcome (combined lung and thoracic cavity score) in the carcase, with pre-vaccination having a potential impact. The lighter the induction weight the more likely it was that the animal would show signs of disease damage in the carcase. The cohort in this study is relatively small (1650 head) and so the number of producers supplying cattle is limited. However, the results suggest that emphasis should be placed on induction weight as a means to reduce the incidence of BRD.

The influence of breed and days on feed (DoF) on marble score is no surprise. It is well documented that cattle fed for longer periods of time on a grain ration will develop superior marbling. Along with this the Angus breed of cattle is known for its marbling ability.

The Hot Standard Carcase Weight (HSCW), Average Daily Gain (ADG) and Fat Depth (P8) of the carcase were all significantly affected by the gross pathology combined disease score and induction weight. The trend was that HSCW, ADG and Fat Depth were all reduced when the combined pathology score increased. This is demonstrating that there is a production effect caused by BRD and that it may have an economic impact.

HSCW was significantly affected by breed, with the trend for Angus cattle to have heavier carcases. This maybe a result of the length of feeding program and target market. Induction weight and the pre-vaccination of cattle prior to feedlot entry also have positive correlations to final HSCW. This result would suggest that combining a vaccination program prior to feedlot entry with heavier induction weights could be considered good protocols to follow in practice. ADG and Fat Depth (P8) were all significantly affected by breed, Induction Weight and season of entry into the feedlot. Cattle entering the feedlot during autumn had higher ADG and Fat Depth. This is not surprising considering the favourable feeding conditions during the Autumn-Winter-Spring period during the trial and with faster growth rates a higher fat depth is expected.

6 Conclusions/recommendations

The significant effect that induction weight and source of cattle (producer) has on disease outcome highlights the fact that disease in the feedlot maybe more of a result of prior management of the cattle. This emphasises the point that disease such as BRD need to be managed with the whole supply chain in mind and can't be considered as disease of feedlots only.

7 Key messages

- Treatment of cattle suspected of having BRD was not significantly correlated with gross pathology outcome at the abattoir. This may be due to poor accuracy of diagnosis or animals having prior exposure to BRD before feedlot entry.