Investigating Bovine Respiratory Disease and Associated Farm Level Risk Factors: A Pilot Study

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ABSTRACT

An estimated 1.9 million animals (Nicholas and Ayling, 2003, Nicholas, 2011) are affected by bovine respiratory disease (BRD) each year in the UK cattle industry with costs estimated at around £60 million annually (NADIS 2007).

The principal pathogens assumed to be implicated in BRD have been identified and their epidemiology and pathogenesis generally understood. A range of effective therapeutic (anti-inflammatory and anti-microbial products) and preventative tools (vaccines) have been developed and offer positive opportunities for control. However, BRD is complex, multi-factorial and despite the available tools continues to represent a threat to cattle health, welfare and farm profitability (Caldow, 2011).

A fundamental appreciation of animal-pathogen-environment interactions is necessary to understand the success and failure of current control measures. Are some current control strategies actually unsuccessful, is knowledge transfer inadequate, are recommendations generally being ignored or are there new developments, pathogens or approaches that merit investigation?

PILOT BRD STUDY

A pilot study was developed to begin to address some of these questions as part of the EBLEX (a division of the Agriculture and Horticulture Development Board - AHDB) research and development programme.

Outline aims of the pilot project:

- To address some of the main factors contributing to BRD outbreaks in commercial UK cattle herds
- To challenge current understanding of BRD in UK cattle herds
- To evaluate potential key messages for knowledge exchange to feed back to the farming industry
- To pilot methodology for comparing risk factors for future studies and for development of a 'Pneumonia MOT' on-farm risk assessment tool for farmers or advisors.

Outline study method:

- Individual investigations at farm level on six study farms comparing risk factors on three high (outbreak) and three low (baseline) incidence BRD herds
- Comparison of baseline factors across baseline and outbreak herds addressing animal, pathogen and environment issues.

The findings of pilot BRD study highlighted 3 main themes emerging:

1. Animal issues - immunity
    a. Stocking rate
    b. Nutrition
2. Environment - housing and ventilation
    a. Housing
    b. Ventilation (inlet/outlet)
3. Pathogens - changing profile of key pathogens
    a. Viruses
    b. Role of BVD
    c. Emerging pathogens (e.g. mycoplasma bovis)

These preliminary findings will be discussed in a practical herd based context.

INTRODUCTION

Bovine Respiratory Disease (BRD) is common in commercially reared beef calves and yearlings in the United Kingdom leading to irreversible lung pathology in affected animals, causing poor welfare and a significant economic loss. An estimated 1.9 million animals (Nicholas and Ayling, 2003) are affected each year, and costs to the UK industry associated with treatments, lower growth rates and calf mortality are significant at around £60 million annually (NADIS, 2007). Up to 20% of all growing calves may present ante-mortem with respiratory disease but 36.6% present with some lung pathology at slaughter. Such lesions may lower growth rates by $\geq$0.2 kg daily and cost the producer around £30 - 80 per animal at risk: that financial loss is increased to £500 when an animal dies (Caldow and Crawshaw 2005; Scott, 2009). BRD is the most common and costly disease of feedlot cattle in the United States (Snowder et al, 2006) and an important cause of losses occurring during the early finishing period in similar units in South Africa (Thompson et al, 2006).

Top Three Conditions at Ante and Post Mortem Inspection in Calves and Cattle in GB as Recorded by FSA/MHS between July 2008 and June 2010*

	Ante Mortem		Post Mortem	
Calves	**Condition**	**%**	**Condition**	**%**
	Pneumonia/Respiratory Disease	19.4	Kidney Lesions	37.5
	Diarrhoea	15.0	Pleurisy/Pneumonia	36.6
	Lameness	14.5	Abscesses	4.9
Cattle	Lameness	27.8	Fluke	43.6
	Pneumonia/Respiratory Disease	10.3	Kidney Lesions	16.0
	Mastitis	8.5	Pleurisy/Pneumonia	11.2

**Observations from a total of 1,698, 89,610, 8,730 and 1,940,504 calves and cattle at ante and post mortem respectively*

It is estimated that in the UK, one in thirteen beef bred calves die in the rearing phase (Hayton, Pocknee & Statham Defra, 2008). Mortality is highest during the first six months of life but certain classes of cattle can be quite vulnerable until they are about ten months of age. A recent industry initiative has been the formation of the National Youngstock Association (NYA) who have raised awareness of the average losses from birth through rearing. Three main issues leading to calf losses are:

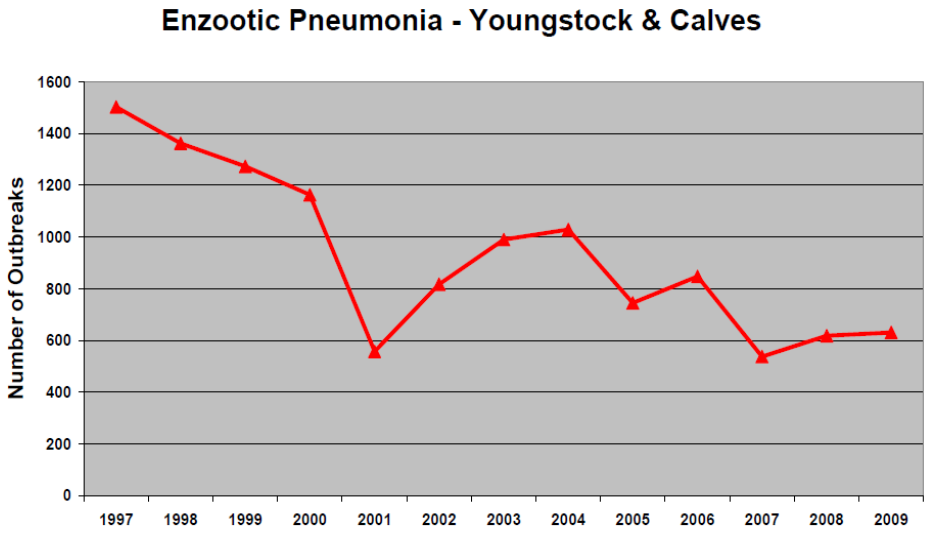
- Scours
- Pneumonia
- Poor sire selection (resulting in calf death at birth)

Scouring is the most common disease in young calves and the greatest single cause of death. However, respiratory disease (pneumonia) is the commonest reason for deaths and

poor performance in young cattle from weaning to ten months of age. Reduced daily liveweight gain is a common consequence of sub-clinical disease.

Calf pneumonia is expensive with costs estimated in one breakdown at £82 per affected suckler calf. Of these costs only 40% are accounted for in vets fees and drugs, 60% were hidden costs such as loss in liveweight gains through reduced feed conversion efficiency resulting in increased time to finishing (Nettleton and Hotchkiss, 2008). However, these costs are probably an underestimate. In the suckler model the loss of liveweight gain was only monitored up to five weeks following the outbreak and therefore the costings didn't take into account loss of daily liveweight gain after this period or potential losses in 'in-contact' seemingly unaffected calves.

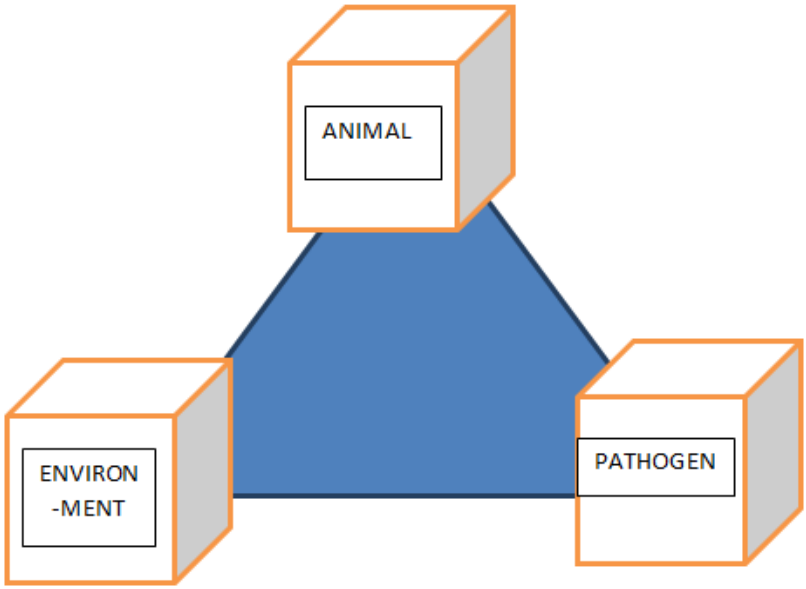
Exactly how much calf pneumonia is present in the UK is not known. Data from AHVLA has been complemented by other sources such as NADIS (see below), but this is not currently comprehensive.



(Source: NADIS)

Why is BRD still such a significant issue for the UK cattle industry? The principal pathogens assumed to be implicated in BRD have been identified and their epidemiology and pathogenesis generally understood. A range of effective therapeutic (anti-inflammatory and anti-microbial products) and preventative tools (vaccines) have been developed and offer positive opportunities for control. However, BRD is complex, multi-factorial and despite the available tools, continues to represent a threat to calf health, welfare and farm profitability (Caldow, 2011).

Whether or not an animal becomes diseased is a balance between the strength of its immunity and the level of the disease challenge it faces. This is never more apparent than in calf pneumonia and is an issue for measuring these calfhood conditions as they remain poorly recorded in general at the current time, despite recent research (DairyCo & RVC) and a national campaign to 'Stop the loss.' Issues such as good colostral management, nutrition and environmental control combined with proactive monitoring of performance, are currently being promoted in the industry.



However, a fundamental appreciation of animal-pathogen-environment interactions in UK beef suckler systems is necessary to understand the success and failure of current control measures. How successful are current control strategies, is knowledge transfer adequate, are recommendations generally being ignored or are there new developments, pathogens or approaches that merit investigation?

PILOT BRD STUDY

A pilot study was therefore developed to begin to address some of these questions as part of the EBLEX (a division of the Agriculture and Horticulture Development Board - AHDB) research and development programme.

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METHODS

Outline study method

- Individual investigations at farm level were carried out on six study beef farms comparing risk factors on 3 lower incidence (baseline) and 3 high incidence (outbreak) BRD herds
- Comparison of baseline factors was then made across baseline and outbreak herds addressing animal, pathogen and environment issues
- Investigations were made and documented as a partnership between practising veterinary surgeons at RAFT Solutions/Bishopton Veterinary Group and a veterinary pharmacy MSc student.

All participating farms were located in Yorkshire.

Recruitment of Low incidence Farms (Baseline)

Three farms were proactively recruited into the baseline group following contact from the veterinary practice and an explanation of the aims and objectives of the study. The criteria for recruitment into this group included:

1. Farmer consent/willingness to participate
2. Suitability of farm business, e.g. good records
3. Beef suckler herd rearing weaned home bred calves
4. Suitability of handling systems to allow baseline data to be collected safely

Upon recruitment initial farm visits were carried out and baseline data was collected for each farm:

1. Serological profiling via coccygeal venepuncture of five 7-10 month old animals for:
    a. Respiratory Pathogens
        i. IBR, BVD, RSV, PI-3, H. Somni, Mycoplasma Bovis.
    b. Trace element blood profiling of five 7-10 month old animals for:
        i. Copper, Vitamin E/Selenium (*cobalt was also tested but laboratory results were considered unreliable so are not included in this report)
    c. Faecal sampling of adult herd and youngstock:
        i. Fluke, enteric worms, Coccidiosis
2. Assessment of livestock buildings including:
    a. Design and measurements
        i. Total floor area, height to ridge outlets and estimates of inlet and outlet ventilation areas
        ii. Assessment of bedding provision and hygiene and moisture levels; as walked round bedded areas, if boots 'squelched' this was noted as a 'positive squelch test', whereas no sinking or squeezing of visible moisture out of bedding was noted as a 'negative squelch test'
        iii. Detailed building plans were drafted.
    b. Ventilation
        i. Assessed semi-quantitatively with multiple smoke bombs to establish smoke clearance times (smoke emitter pellets lit and time recorded until smoke was no longer apparent in pen airspace)

ii. Assessed qualitatively by objective assessment of smoke clearance patterns (descriptive review of direction of travel of smoke i.e. up out of outlet ridge or transversely across pens)

c. Humidity
    i. Assessed by humidity meter (Hesska instruments)
d. Draughts
    i. Air speed at calf level measured at multiple points per shed (Hesska instruments)
e. Stocking rates
    i. Total kg of beef per building/m^2 was estimated at the time of the farm visit. This was done by counting stock numbers in age categories in each pen and using farm records to estimate pen weights from mean individual weights present on a measured floor area.
f. Temperature
    i. Recorded at air speed and humidity measurement points using the same multi-measurement instrument (Hesska instruments)
g. General observations
    i. presence of cobwebs, water leaks etc. were noted
h. Body condition score
    i. noted on the farm visit on a group basis in each pen during the above building assessments.

These herds may have been high incidence BRD in the past but had taken steps to proactively reduce disease.

Recruitment of High Incidence Farms (Outbreak)

At the outset of the study, all eligible beef farms (both suckler and finishing herds) served by the practice were contacted using a combination of post, phone calls and announcements at on farm discussion groups. The aim was to raise awareness of the study and encourage reactive participation in the event of a BRD outbreak to facilitate recruitment of three suitable high incidence herds.

Upon recruitment onto the project, farm visits (1 to 3) were carried out to assess and treat affected animals appropriately and collect initial clinical data.

The initial visit:

1. Clinical assessment and appropriate treatment of sick stock
2. Diagnostics to identify outbreak cause
    a. Blood sampling of acutely affected animals for serological assessment (first of two paired* samples to measure specific seroconversion to a panel of respiratory pathogens).
        i. Respiratory viruses: IBR, BVD, RSV, PI-3
        ii. H. Somni, Mycoplasma Bovis
    b. Bronchioalveolar lavage to collect samples from the respiratory tract of affected animals

(**Paired serology involves blood sampling of an acutely affected animal, repeated 3 weeks later. First and second samples are used to assess if there is rising antibody titre to specific pathogens*).

On all outbreak farms a second visit was carried out 21 to 28 days later to facilitate further data collection including:

1. Further diagnostics
   i. Blood sampling of affected animals to take second of paired samples and so allow sequential serological assessment to identify seroconversion (development of antibodies) to respiratory viruses: IBR, BVD, RSV, PI-3
   ii. H. Somni, Mycoplasma Bovis
2. Trace element profiling of five clinically affected 7-10 month old animals for:
   a. Copper, Vitamin E/Selenium *
      (*profiling also undertaken for cobalt but were unreliable calibration and are therefore not presented)
3. Sampling & observation of adult herd and youngstock:
   a. As per protocol for baseline farms
4. Assessment of livestock buildings
   a. As per protocol baseline farms

An interview was also conducted with the farmers to gain background information relating to the farm management system and historical disease issues on the farm.

RESULTS

Data collected essentially comprises three elements:

i. Animal data - nutrition, stocking density, trace element status, parasite burden etc.
ii. Pathogen data - serological status regarding a panel of known respiratory pathogens
iii. Environmental data - space, ventilation and ambient conditions

These data are described for the three baseline herds and then the three outbreak herds. Results of significance are highlighted in blue/red and referenced in the discussion text.

The appendices to this report provide references against which the farm results were compared.

BASELINE FARMS

1. Baseline Farm A – Non outbreak

Background

Approximately 160 cow commercial suckler herd finishing home bred calves for beef production. Replacements bought in as required.

Health status

This farm historically has had a high incidence of BRD with around 7% spring calves and 25-33% autumn calves affected. Investment in new buildings has been undertaken over the last few years.

The suckler herd is vaccinated for BVD, IBR, and leptospirosis. Youngstock are vaccinated with a multivalent vaccine for BRD (Rispoval R4; Pfizer Animal Health) and lungworm (Huskvac; MSD). Body condition was scored at 2.25 - 2.5 for suckler cows. A serological survey of a youngstock cohort was carried out as described in the methodology. As highlighted by the data in ***Table 1***, although trace element and faecal profiles were in general unremarkable and within normal ranges (see appendix 1 for reference ranges), all animals showed evidence of previous exposure to RSV with some scattered exposure to PI-3 virus (results highlighted in blue).

Table 1: *Animal sampling results for baseline farm A*

Trace element profiles							**Faecal samples**	
Animal ID:	**794**	**796**	**799**	**804**	**807**		**Fluke egg count**	Not detected
Copper (9-19)	13.9	10.5	11.5	8.9	10.5		**Worm egg count**	<25
Vit E/Sel (>30)	54.4	57.9	75.1	x	80.9		**Coccidial count**	0
Serological screen								
Animal ID:	**794**	**796**	**799**	**804**	**807**			
BVD Ab	0.08	0.24	0.19	0.11	0			
H. Somni	<1/10	<1/10	<1/10	<1/10	<1/10			
IBR	0.2	0.18	0.24	0.04	0.04			
Mycoplasma	negative	negative	negative	negative	negative			
RSV Ab	0.82	0.53	0.78	0.99	0.9			
Pi3 Ab	0.42	0.08	0.28	0.15	0.07			
Lepto	negative	negative	negative	negative	negative			

Buildings

Cattle are housed in a purpose built multispan building with airspace shared between different management groups and age groups. However, the building is insufficient in terms of ventilation with outlets significantly lower than required, as shown in ***Table 2***.

***Table 2**: Building results for baseline farm A*

Left side

Stock

Type	Cows	Heifers	Bull youngstock	**Total**
No.head	44	48	40	132
Weight est av. (kg)	550	400	350	
Total kg	24200	19200	14000	57400
kg/head av.				434.8

Building

Area (m^2)	893.04
Vol (m^3)	6537.05
Loafing (inc.race) m2	148.84
Loafing (inc.race) m3	1089.51

Stocking density (excluding loafing)

	Actual	**Ideal**
m^2/head	6.77	4.4
m^3/head	49.52	-
kg/m^2	64.27	113.5
kg/m^3	8.78	-

Ventilation

Height outlet to inlet (m)	3.66		
Height factor	0.52		
	Actual	**Ideal**	**Type**
Inlet area (m^2)	76	31	sidewall space board 1in4 removed (29.1m^2) other sidewall restricted therefore include sidewall opening (12.1m^2) plus gable end ventilation back space board (18.61m^2) and front space board and gaps (23.5m^2)
Outlet area (m^2)	2.56	7.75	ventilated crown cranked ridge

Right side

Stock

Type	Cows	Calves	Older calves	Bulls	**Total**
No.head	62	30	39	4	135
Weight est. av. (kg)	550	90	140	900	
Total kg	34100	2700	5460	3600	45860
kg/head av.					339.7

Building

Area (m^2)	1041.88
Vol (m^3)	7626.56

Stocking density

	Actual	**Ideal**
m^2/head	7.72	3.9
m^3/head	56.49	-
kg/m^2	44.02	87.5
kg/m^3	6.01	-

Ventilation

Height outlet to inlet (m)	3.66		
Height factor	0.52		
	Actual	**Ideal**	**Type**
Inlet area (m^2)	50.83	30	sidewall space board (16.96m^2) other sidewall restricted therefore include gable end back space board (18.61m^2) and front space board and gaps (15.27m^2)
Outlet area (m^2)	2.56	7.51	Crown cranked ventilated ridge

Appendix 2 explains how height factor is calculated.

Significantly, as shown by the figures in red, outlet ridge ventilation was below ideal specification for these buildings; a capped ridge system was in use rather than open or protected ridge openings.

Internal environment

***Table 3**: Ventilation and temperature details for baseline farm A*

Left side						
	Point					
	1	**2**	**3**	**Average**	**Outside**	**Difference**
Temperature°C	4.7	4.5	4.6	4.6	4.8	-
RH %	52.3	50.5	52.9	51.9	46.5	5.4
Air Speed m/s	<0.4	<0.4	<0.4	-	x	-
Smoke Bomb		**1st**		**2nd**		
Total time to clear		1 min 50 sec		1 min 40 sec		
Stocking		Full		Full		
Description	Lifts to ridge, drift down to shed front, sinks into feed passage,					
	leaves out front openings					
Right side						
	Point					
	1	**2**	**3**	**Average**	**Outside**	**Difference**
Temperature°C	4.8	4.7	4.7	4.73	4.8	-
RH %	54	58	54.2	55.4	46.5	8.9
Air Speed m/s	<0.4	0	0.7	-	x	-
Smoke Bomb						
Total time to clear	>4 min					
Stocking	Full					
Description	Lift to ridge, fall down opposite side, drift through building not					
	clearing wall					

Score	**Factor**
0 (poor)	Dust
1 (unsatisfactory)	Excretory waste, adjoined building to other cattle, fumes, bedding clenliness (straw bed)
2 (satisfactory)	Odour, water contamination and access, feed contamination
3 (good)	Light, chemicals, bedding depth (straw bed), bedding clenliness (cubicles), drainage, feed access
Observations	Trough leaks onto bedding, cobwebs in both buildings least so on left side of left building where space board removed 1 in 3
Squelch test result	Pass some pens, fail some areas of straw bed in some pens

As shown by the figures highlighted in red in the above ***Table 3***, some areas of the multi span building exhibited drafts, with air speed measured at >0.7m/s at point 3, and calf level temperatures that were sub-optimal compared to reference ranges (see Appendix 3). Bedding was also wet in some areas (positive 'squelch' test) and ventilation inadequate with extended smoke clearance times at >4 minutes and cobweb accumulation on purlins. Air quality scores were graded qualitatively on a 0 - 3 scale as shown above and were generally satisfactory apart from shared airspace issues.

Management

Animals are managed and grouped by age and weight. However, all groups are housed within the same airspace. The farm has no quarantine or isolation facilities and practices no proactive biosecurity.

2. Baseline Study Farm B (2011/12) – Non outbreak

Background

Study farm B was a 200 cow commercial suckler herd with 160 spring calving cows and 40 autumn calving cows. The farm intensively fattens homebred bulls and heifers for slaughter, and rears heifer replacements.

Health status

This herd had a high incidence of BRD historically with significant numbers of animals affected in the fattening shed (building 2) in the 2010/11 winter housing period. However, significant changes have been made to both the main building and vaccination policy since this outbreak.

The herd has known health status managed through proactive annual health screening and vaccination of suckler cows and breeding heifers for IBR, BVD and leptospirosis.

Spring calves receive RSV, PI-3 and IBR protection via two intranasal vaccinations (Rispoval Intranasal, Pfizer Animal Health; Bovilis IBR Marker Live, MSD) at winter housing. Autumn calves received intranasal RSV, and PI-3 vaccination at 7 days old (Rispoval Intranasal; Pfizer Animal Health) supplemented by intramuscular vaccination for BVD, RSV, and PI-3 (Rispoval R3; Pfizer Animal Health) and IBR protection via intranasal vaccination with Bovilis IBR Marker Live, MSD from 9 - 12 weeks old.

Weights were measured intermittently when handled, as well as specifically for this study. Stocking density increased significantly during the housed period as a consequence of rapid growth rates; of ten youngstock bulls, eight exceeded 1.74kg/day DLWG during March 2012.

***Table 4**: Animal sampling results for baseline farm B (2011/12)*

Trace element profiles - 2012						
Animal ID	**101821**	**501769**	**501839**	**601742**	**701806**	**701841**
Copper (9-19)	12.7	12.9	13.4	14.1	12.9	12.8
Vit E/Sel (>30)	164.1	160.2	164.4	205.2	194.8	165.3
Faecal samples - 2012						
Fluke egg count not detected						
Worm egg count <25						
Coccidial count not detected						

All blood and faecal results were in normal range.

Buildings

Building 1 housed cows and 2011 autumn calves on one side of a central partition. A further pen of cows and autumn born calves were housed alongside a pen of cows on the additional side and one bull was present in each pen. The cows and calves were housed on straw beds with a large creep area and a feed trough running along each exterior sidewall. The creep areas were 48.8m² on the left side and 29.3m² on the right side equating to 2.5m²/head and 3.3m²/head respectively.

Building two housed the fattening cattle in straw bedded courts with a feed passage running down the middle. The 2010 outbreak data for this farm (***Tables 15 and 16***) and modifications referred to this building. Ventilation was satisfactory in both buildings at the time of the farm visit.

Table 5*: Building results for baseline farm B*

Building 1					
Stock					
Type	Cows	Calves	Bull	**Total**	
No.head	39	28	3	70	
Weight est. av. (kg)	600	90	900		
Total kg	23400	2520	2700	28620	
kg/head av.				408.86	
Building			**Stocking density**		
Area (m^2)	586.1			**Actual**	**Ideal**
Vol (m^3)	4647.4		m^2/head	8.37	6
			m^3/head	66.39	-
			kg/m^2	48.84	100
			kg/m^3	6.16	-
Ventilation					
Height outlet to inlet (m)	3.965				
Height factor	0.5				
	Actual	**Ideal**	**Type**		
Inlet area (m^2)	57	16.52	sidewall space board (29.58m^2) plus feed opening (27.45m^2)		
Outlet area (m^2)	5.36	4.13	Open ridge 3.575x0.25m per bay		
Building 2					
Stock					
Type	Steers	Cows/heifers	Bull youngstock	**Total**	
No.head	10	49	73	132	
Weight est. av. (kg)	400	400	550		
Total kg	4000	19600	40150	63750	
kg/head av.				482.95	
Building			**Stocking density**		
Area (m^2)	991.28			**Actual**	**Ideal**
Vol (m^3)	6046.82		m^2/head	7.51	4.6
			m^3/head	45.81	-
			kg/m^2	64.31	109
Ventilation			kg/m^3	10.54	-
Height outlet to inlet (m)	2.44				
Height factor	0.63				
	Actual	**Ideal**	**Type**		
Inlet area (m^2)	52.86	41.25	1 in 3 spaceboard sidewalls		
Outlet area (m^2)	12.26	10.31	Open ridge full length building x 0.264m width		

Internal environment

Draughts were evident at one point in building two, but this was not consistently reflected using the instruments utilised in this study (Hesska instruments). Environmental testing was unable to be completed in building one because of safety issues over access with mixed cows and calves at foot. Environmental observations and air quality score was poor in

building two, with presence of odour and a stale, stuffy atmosphere. The concentrate feed was also dusty and coughing was evident in a number of youngstock.

***Table 6**: Environmental results for baseline farm B*

Building 2													
	Point												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Average**	**Outside**
Temperature^{O}C	15.6	16	16	15.8	15.8	16	15.5	15.8	15.7	15.6	16	15.8	x
RH %	48.5	54	53	51	50.2	50.3	48.7	53	46.5	47.2	54.5	50.63	x
Air Speed m/s	<0.4	0	0	0	0	0	0	0	0	0	0	0	x
Smoke Bomb													
Total time	1 min 40 sec												
Stocking	Half												
Description	Rises to ridge, falls down other side but above animal height												

Score	**Factor**
0 (poor)	Odour
1 (unsatisfactory)	Dust
2 (satisfactory)	Excretory waste, light, ad lib feed access building 2
3 (good)	Other stock, fumes, chemicals, drainage, depth and clenliness bedding, all other feed and water access and contamination
Observations	Coughing in youngstock building 2, bloat problem in youngstock building 2
Squelch test result	Pass

Multiple temperature recordings were made as a consequence of repeated air speed measurements using the same instrument.

Management

Animals were grouped separately in pens according to age and weight but were mixed within one building and airspace.

3. Baseline Study farm C – Non outbreak

Background

Study farm C was a suckler herd with 35 weaned calves housed in the area of investigation with a further two sheds housing 72 in calf spring suckler cows. Replacements were bought in on an open herd basis. The full range of information from data collection was not returned to report full results because of the sad death of a family member on this farm mid-study.

Animals were given intranasal IBR vaccination (Bovilis IBR Marker Live) at housing reflecting the positive serological screen for IBR in all sampled animals as shown in the figures in blue in ***Table 7***. Two of 5 also tested positive for RSV and PI-3 indicating exposure (figures also highlighted in blue). Dams were vaccinated for BVD but the remaining herd health status was not reported. As shown by the figures in red, all 5 animals were below reference range for selenium with the lowest being 15.5, and two of the 5 tested were below reference range for copper.

Table 7*: Animal sampling results for baseline study farm C*

Trace element profiles							**Faecal samples**	
Animal ID:	**700**	**708**	**728**	**739**	**740**		**Fluke egg count**	Negative
Copper (9-19)	6.9	7	9.4	12.9	14.9		**Worm egg count**	Negative
Vit E/Sel (>30)	28.1	17.1	15.5	16.9	22		**Coccidial count**	Negative
Serological screen								
Animal ID:	**700**	**704**	**708**	**739**	**740**			
BVD Ab	0.04	0	0.01	0.02	0.01			
H. Somni	negative	negative	negative	negative	negative			
IBR	0.38	0.44	0.64	0.44	0.47			
Mycoplasma	negative	negative	negative	negative	negative			
RSV Ab	0.14	0.2	0.15	0.44	0.36			
Pi3 Ab	0.29	0.12	0.65	0.1	0.14			

Buildings

The weaned calves were housed in a mono-pitched unit adjoining a building used to store straw which was filled over winter. The area for the calves consisted of an equally split straw bedded area and concrete feed area. With no ventilation down the adjoining sidewall, the remaining sides provided ventilation through open areas and space boarding and therefore had sufficient inlet and outlet area as shown in ***Table 8.***

Table 8: *Building results for baseline farm C*

Stock			**Stocking density**			
Type	Weaned calves			**Actual**		**Ideal**
No. head	35			**Total**	**Bedded**	**Bedded**
Weight av. (kg)	130		m^2/head	4.78	2.4	2.4
Total kg	4550		m^3/head	26.27	-	-
kg/head av.	130		kg/m^2	27.17	54.3	58
			kg/m^3	4.95	-	-
Building						
Area (m^2)	167.45					
Vol (m^3)	919.3					
Ventilation						
Height outlet to inlet (m)	0					
Height factor	0					
	Actual	**Ideal**	**Type**			
Inlet area (m2)	51.35	8.4	Space boarding 2 sides (12.28m^2), open areas (39.07m^2)			
Outlet area m2	39.07	2.1	Open areas			

Internal environment

Data from this farm was incomplete as discussed above. Of the internal environment results for temperature (average 8^{o}C) and air speed reported (smoke bomb clearance took 17 seconds), the average results were within target range. Scoring results were not fully returned, but some damp straw bedding was reported in one of the buildings housing adult animals. The evidence of housing next to a straw shed could also have increased dust levels in the calf airspace.

OUTBREAK HERDS

1. Outbreak farm D

Background

Outbreak farm D was a 30 cow recently closed suckler herd with an outbreak of BRD in late December 2011 affecting autumn born calves which were housed in early December. Two were badly affected and 13 were showing early clinical signs. The herd was not previously vaccinated for BRD pathogens.

Background Health

Historically, a low incidence herd for BRD operating a closed herd system for two years with one recognised calf case each year but no outbreaks. The health status of the herd was unknown for BVD, IBR, leptospirosis, lungworm and coccidiosis. The farm was positive for fluke in the sheep on the farm, although the farmer had noted no problem in the cattle. Body condition score for the autumn calving cows was between 1.75 and 2.5. The spring calving cows scored 2.5 to 3.0.

Table 9: *Animal sampling results for outbreak farm D*

Trace element profiles									**Faecal samples**			
Animal ID		**422**	**423**	**424**	**430**	**431**			**Fluke egg count** not detected			
Copper (9-19)		2.2	5.9	2.2	8.5	3.9			**Worm egg count** <150			
Vit E/Sel (>30)		8.7	16.4	12.9	25.4	16.6			**Coccidial count** <50			
Paired Serology												
Animal ID	**423**		**424**		**425**		**428**		**430**		**433**	
	FOP	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**
BVD Ab	0.15	0.04	0	0	1.07	0.49	1.26	0.98	1.33	1.2	0.3	0.09
H. Somni	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
IBR	0.01	0	0	0.01	0	0.01	0.01	0.01	0	0	0.01	0
Mycoplasma	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
RSV Ab	0.41	0.47	0.14	0.15	0.19	0.09	0.14	0.08	0.5	0.41	0.69	0.26
Pi3 Ab	0.02	0.23	0.09	0.35	0.51	0.27	0.31	0.17	0.48	0.33	0.23	0.15

As shown in the above ***Table 9,*** paired serology results were negative apart from just a couple of calves showing rising antibody titres to PI-3 from the first to second of the paired samples, consistent with recent exposure to PI-3. Background health screening and trace element profiling revealed that copper and vitamin E/selenium were deficient in *all* calves (as shown by the trace element figures in red). This was an upland commercial suckler herd with limited scope for additional nutritional management and although no conclusive pathogen was identified, concerns regarding immune status in this herd were significant with both trace element, general nutrition and unmanaged BVD status.

The paired serology results were consistent with a mix of previous exposure/maternally derived antibodies and some recent seroconversion to PI-3 (2 of 5 clinically affected animals, as shown by the data highlighted in red). No other seroconversion was detected. However, 4 of 6 animals demonstrated positive titres for BVD and 3 out of 6 animals showed positive titres to RSV.

Buildings

The calves affected were housed in a single shed adjacent to the spring calving suckler cows and one bull. Airspace was shared with approximately 20 fat lambs. The shed was an open fronted shed with a loafing area for free movement of cattle housed in that building.

***Table 10**: Building results for outbreak farm D*

Stock						**Stocking density (excl loafing)**			
Type	**Cows**	**Calves**	**Bull**	**Total**			**Actual**	**Ideal**	
No. head	15	15	1	31		m^2/head	4.59	6	
Weight est. av. (kg)	600	140	900			m^3/head	19.6	-	
Total kg	9000	2100	900	12000		kg/m^2	84.3	100	
kg/head av.	-	-	-	387.1		kg/m^3	19.7	-	
Building									
Area (m^2)	142.33								
Vol (m^3)	607.73								
Loafing area (m^2)	118.09								
Ventilation									
Height outlet to inlet (m)	0								
Height factor	0								
	Actual	**Ideal**	**Type**						
Inlet area (m2)	38.42	11.66	Open front (36.4m^2) and wall cladding gaps (2.08m^2)						
Outlet area m2	36.34	2.91	Open front, closed ridge						

As an open fronted monopitch design, outlet and inlets were the same and so these values were shown as zero in the table above. Ventilation achieved the target requirements at the given stocking density considering the building alone as well as the additional access to the loafing area.

Internal environment

***Table 11**: Environmental results for outbreak farm D*

Environmental results								
	Point							
	1	**2**	**3**	**4**	**5**	**Average**	**Outside**	**Difference**
Temperature°C	10.3	10	10	9.5	9.7	9.9	8	1.9
RH %	x	52	50.2	50.4	51.2	50.95	48	2.95
Air Speed m/s	<0.4	<0.4	<0.4	0	0.7	-	1.4	-
Smoke Bomb		**1st**		**2nd**				
Total time to clear		2 min 26 sec		2 min 23 sec				
Stocking		Half		Full				
Description	Rise, lip out open front, recirculation to calf height after 2 min but due to eas							

Score	**Factor**
0 (poor)	Excretory waste, shared air lambs, bedding clenliness, drainage
1 (unsatisfactory)	Water contamination
2 (satisfactory)	Water access, odour
3 (good)	Dust, fumes, chemicals, light, bedding depth, feed access and contamination
Observations	Condensation on roof sheeting, staining of timber purlins, wet floor in and out, trough in bedding area
Squelch test result	Fail

Variation in conditions was apparent here with the open fronted design limiting control within some parts of the building. Moisture management was unsatisfactory in some areas, with squelch test results failing standards, wet floors and roof condensation.

Management

All animals were grouped together creating mixed age and weight groups, with no quarantine of clinically affected stock.

No biosecurity policies had been historically in place prior to a recent decision to close the herd.

2. Outbreak Farm E

Background

This farm was one site of a large store cattle operation purchasing animals of varying ages from multiple locations for finishing or reselling as strong stores as market price dictated. Baseline herds were recruited on criteria including specifically homebred stock in order to further investigate herd health status. However, the timeframe of the study was mid-winter and post-autumn high risk period; consequently ALL beef herds had been notified of the study and opportunities for taking part, including store units such as farm E.

This outbreak occurred in late January. The animals were housed in early January 2012 with further animals added throughout the month. The outbreak initially affected three animals clinically from a group of 12, with deaths of two animals during the outbreak. All purchased animals were vaccinated with a live IBR marker intranasal vaccine on arrival.

***Table 12**: Animal sampling results for outbreak farm E*

Trace element profiles									**Faecal samples**			
Animal ID:		**300242**	**400243**	**100240**					**Fluke egg count** not detected			
Copper (9-19)		7.8	11.8	x					**Worm egg count** <50			
Vit E/Sel (>30)		89.6	113.1	175.6					**Coccidial count** <50			
Paired Serology												
Animal ID:	**300242**		**400243**		**700232**		**100180**		**300588**		**400199**	
	FOP	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**
BVD Ab	0.04	0.05	0.05	0.03	0.02	1.21	x	0.18	x	x	x	x
H. Somni	negative	negative	negative	negative	negative	negative	x	negative	x	negative	x	negative
IBR	0	1.1	0.04	0.96	0.03	1.06	x	1.21	x	0.84	x	0.95
Mycoplasma	x	positive	x	positive	x	positive	x	positive	x	positive	x	positive
RSV Ab	0.09	0.44	0.27	0.23	0.38	0.54	x	0.61	x	0.82	x	0.55
Pi3 Ab	0.4	0.46	0.62	0.79	0.2	0.98	x	0.57	x	0.8	x	0.77

As can be seen from the results above, *all* animals showed evidence of exposure to mycoplasma during the outbreak. Limited seroconversion also occurred for BVD, RSV and PI-3. IBR seroconversion also occurred, but intranasal vaccines were given at onset of outbreak. The mycoplasma seroconversion is potentially significant in this case as vaccination against viral BRD was unsuccessful and this emerging BRD pathogen represents a challenge for control in a herd purchasing animals with low biosecurity measures.

The results also highlight the challenges of handling and treating animals in the face of an outbreak. The farmer would only consent to three animals being successfully sampled for paired serology due to the perceived stress of handling and the adverse effect this may have on the group, following the death of three clinically affected animals.

Buildings

The cattle involved in this outbreak were housed in a building designed for grain/feed storage with a temporary penned area for the cattle.

***Table 13**: Building results for outbreak farm E*

Indoor building								
Stock				**Stocking density (area pen)**				
Type	**Stores**				**Actual**	**Ideal**		
No. head	11			m^2/head	8.88	4.2		
Weight est. av. (kg)	390			m^3/head	48.75	-		
Total kg	4290			kg/m^2	43.92	92		
kg/head av.	390			kg/m^3	8	-		
Building								
Area pen (m^2)	97.68							
Area pen (m^3)	536.24							
Vol (m^3)	167.45							
Loafing area (m^2)	881.7							
Ventilation								
Height outlet to inlet (m)	2.44							
Height factor	0.63							
	Actual	**Ideal**	**Type**					
Inlet area (m2)	29.21	3.3	One sidewall pace board (5.21m^2), other sidewall restricted					
Outlet area m2	0.64	0.82	therefore front gable end space board (4.5m^2) and					
			open doorway (19.54m^2) included ventilated crown					
			cranked ridge					
Outdoor building								
Stock						**Stocking density**		
Type	Cows	Calves	Stores	**Total**			**Actual**	**Ideal**
No. head	1	1	6	8		m^2/head	13.95	4.2
Weight est. av. (kg)	600	90	400	-		m^3/head	75.54	-
Total kg	600	90	2400	3090		kg/m^2	27.68	92
kg/head av.	-	-	-	386.25		kg/m^3	5.11	-
Building								
Area (m^2)	111.63							
Vol (m^3)	604.33							
Ventilation								
Height outlet to inlet (m)	1.22							
Height factor	0.9							
	Actual	**Ideal**	**Type**					
Inlet area (m2)	69	-	Open front (58.61m^2) and space board (10.42m^2)					
Outlet area m2	59.43	-	Ventilated crown cranked ridge and open front					

The ***Table 13*** above shows that the ventilation for the indoor building is less than the target value with outlets being insufficient for the number of cattle housed. The ventilation for the

outdoor building was estimated as sufficient being an open fronted building, but could not consistently be compared against target values due to the low stocking density.

Internal environment

***Table 14**: Environmental results for outbreak farm E*

Indoor building								
	Point							
	1	**2**	**3**	**4**	**Average**	**Outside**	**Difference**	
Temperature°C	16.9	16.9	17	16.8	16.9	14.5	2.4	
RH %	42.8	42	42.8	44.3	42.98	43	0.02	
Air Speed m/s	0	0	0.6	0	-	2.2	-	
Smoke Bomb								
Total time to clear	2 min 5 sec							
Stocking	Full							
Description	Lingers at low level, rises, lingering, falls and lip out door but clear of cattle height							
Outdoor building								
	Point							
	1	**2**	**3**	**4**	**5**	**Average**	**Outside**	**Difference**
Temperature°C	15.8	15.7	15.4	16	15.7	15.72	14.5	1.22
RH %	43	43	43	43	44	43.2	43	0.2
Air Speed m/s	0	0	0	0	0	-	2.2	-
Smoke Bomb								
Total time to clear	1 min 30 sec							
Stocking	Full							
Description	Rises and circulates to open front, lips out							

Score	**Factor**
0 (poor)	Dust
1 (unsatisfactory)	Adjoined to other cattle, fumes
2 (satisfactory)	Excretory waste, drainage, bedding clenliness and depth, food and water access
3 (good)	Odour, light, chemicals food and water contamination
Observations	Indoor building in multiuse - cattle, hay and machinery store
Squelch test result	Pass

As shown above, moisture management was generally satisfactory but some limited dust and smoke clearance delays were apparent, and elevated air speed was noted at one site.

3. Outbreak farm F (2010)

This data was taken from building 2 mentioned in the baseline farm analysis (Table 5), in the 2010 winter housing season when the farm suffered a large scale BRD outbreak clinically affecting 80 - 90% of all stock housed in the affected building.

Table 15: *Paired serology results for animals tested during 2010 outbreak farm F*

Paired Serology: 2010 Outbreak										
Animal ID:	**41**		**47**		**68**		**115**		**136**	
	FOP	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**	**FOP**	**SOP**
BVD Ab	0.04	0	0.07	0	0.24	0.12	0.08	0	0.12	0.06
H. Somni	x	negative	x	negative	x	negative	x	negative	x	negative
IBR	0.36	0.22	0.31	0.28	0.18	0.12	0.08	0	0.12	0.06
Mycoplasma	1.02	0.95	1.02	1.14	1.29	1.22	0.7	0.69	0.88	1.08
RSV Ab	0	0.08	0	0.46	0.07	0.22	0.02	0.15	0.27	0.43
Pi3 Ab	0.71	0.59	0.56	0.65	0.36	0.22	0.02	0.15	0.27	0.43

Table 15 shows some evidence of recent seroconversion to RSV (as shown by results highlighted in red), plus historic exposure to PI-3 and IBR (blue results highlighted).

Table 16: *Building results for 2010 outbreak farm F*

Building 2 - Outbreak 2010						
Stock				**Stocking density**		
Type	**Bulls**				**Actual**	**Ideal**
No. head	150			m^2/head	6.6	4.6
Weight est. av. (kg)	505			m^3/head	40.31	-
Total kg	75750			kg/m^2	76.42	109
kg/head av.	505			kg/m^3	12.53	-
Building						
Area (m^2)	991.28					
Vol (m^3)	6046.82					
Ventilation						
Height outlet to inlet (m)	2.44					
Height factor	0.63					
	Actual	**Ideal**	**Type**			
Inlet area (m2)	30.85	45.36	Space board sidewalls			
Outlet area m2	x	11.34	Partly open ridge			

Although this outbreak was typically multifactorial, with high stocking density of double-muscled breeds and severe weather conditions, issues with ridge ventilation design were potentially highly significant in addition to limited air inlets. In response to previous assessment of poor outlets, extremely large outlets were cut in the ridge sheets. Unfortunately, smoke bomb testing post-outbreak revealed that excessive outlets were creating a down-draft effect and smoke traversed the entire building horizontally throughout all pens. This effect was compounded by a 'wind-tunnel' effect along the central passage resulting from open doors intended to promote ventilation.

During the summer following the outbreak, modification of the ridge to an upstand protected design but of much narrower and calculated dimension (Kelly, 2002; Ohnstad, 2010b) combined with closure of the end doors resulted in effective smoke clearance patterns and may have contributed to a winter 2011 free of significant BRD.

DISCUSSION

The finite scope and data characteristics of such a pilot study inevitably limit the statistical power of analysis possible. The role of this pilot study was principally to draw comparisons within and between farms and consequently to explore the potential for a wider study as well as to highlight key areas for knowledge exchange in the industry.

The key findings of pilot BRD study were of THREE main themes emerging:

1. Animal issues - immunity

    - Species characteristics
    - Stocking rate
    - Nutrition

2. Environment - housing and ventilation

    - Housing
    - Ventilation (inlet/outlet)

3. Pathogens - changing profile of key pathogens

    - Viruses
    - Role of BVD
    - Emerging pathogens (e.g. Mycoplasma bovis)
    - Biosecurity issues with purchased stock

ANIMAL

Functionally, most of the conducting airways of the bovine respiratory tract are ciliated and mucus covered, driving dust, debris and microorganisms towards the pharynx as a mechanical defence. Stressors and damage through poor air quality and cold stress will lead to impairment of this action with critical cells having a limited ability to recover. If failure to remove harmful material results (Veit and Farrell, 1978; Kainer and Will, 1981; Caldow, 2011), pathogens will overcome the defences (Caldow, 2011).

Species differences & stocking rate:

Murray (2011) described species-specific characteristics of the bovine lung that increases its susceptibility to upper respiratory tract infections and limits the effectiveness of treatments administered:

Small lung volume: body size ratio - particularly significant in heavy or double muscled breeds

Large dead space ventilation

- limited respiratory reserve
- relatively poor phagocytic (pathogen engulfing) capacity of macrophages in lower airway that reduces bacterial clearance

No collateral ventilation of alveoli

Low inter-dependence – 'tethering'
- collapse of functional lower airway exchange unit is very slow to 're-pneumonise' (repair by air cavities in the lung tissue being re-formed)

Biochemical dysfunction leading to vasoconstriction
- Constriction of blood vessels compromises blood supply which lowers oxygen tension and pH in diseased lung

Poorly developed fibrinolytic system
- fibrin proliferation is common and leads to scarring within parenchyma (lung tissue)

Cattle have a small physiological gas exchange capacity relative to baseline oxygen needs compared with other mammals (Kainer and Will, 1981). The small gas exchange capacity also means that during exertion pulmonary clearance is slower which may decrease resistance to infection (Veit and Farrell, 1978). This is particularly an issue in double muscled breeds where the mismatch between high metabolic requirements and low lung capacity is most dramatic. This was an issue on Outbreak farm F where very fast growing continental breed cattle were particularly susceptible to challenge in a poorly ventilated building and additionally experienced rapid increase in stocking rate as autumn progressed.

Nutrition:

Immunity is influenced by nutritional status (Goff, 2008). Additionally, the role of vitamin E and selenium has been evaluated in immune performance context and although debate exists, it seems that genuine deficiency of selenium and vitamin E may contribute to impaired immune performance as in outbreak farm A.

Friton (2005), Lockwood (2003) and Lekeux (2007) all describe studies or opinions that assert the role for non steroidal anti-inflammatory drugs (NSAIDs) in managing BRD. Improved daily liveweight gain and reduced pulmonary consolidation are described as benefits of NSAID use in addition to antibiotics. Feed input represents a major variable cost in beef production and so as outlined above, prevention of reduced feed conversion efficiency (FCE) as a result of BRD related lesions offers a potential cost-effective role for NSAIDs. The exact cost-benefit depends specifically on how much NSAIDs cost and how much the variable cost of reduced FCE is offset in each case. Preventing mortality may improve the cost-effectiveness of NSAID further.

From a pathophysiological (disease mechanisms) perspective there are three key features that determine the success of any therapy for BRD; the capability to restrict growth and replication of opportunistic secondary bacteria that colonise lungs following upper airway viral infections, support for both the innate and acquired immunological defence mechanisms in the face of infections, and provision of affected calves with an environment suitable for their recovery.

ENVIRONMENT

The risk factors for BRD increase in larger rearing and finishing units, with higher stocking densities, housing and inadequate ventilation (Snowder et al 2006; Thompson et al 2006), unknown health status of bought-in calves and mixing cattle of different ages (Step et al 2008). Kelly (2002) and Ohnstad (2010 a&b) described how inadequate inlet and outlet ventilation combined with poor moisture management in leaky, poorly drained buildings offer favourable conditions for pathogens in addition to compromising animal immunity.

This was particularly an issue for outbreak farms D, E and F where limited control of either air outlet or inlet resulted in circulation of pathogens throughout all animals in a building or exposed vulnerable animals to draughts with compromise of immune defences. Similarly, outbreak herd D was unable to manage moisture levels in the building as effectively as hoped with a consequently increased pathogen challenge and compromised animal immunity.

Options for controlling BRD are widely available but there are no cost-benefit analytical packages available currently in the UK that allow individual farmers and their veterinary surgeons to make better-informed decisions for implementing the best disease control strategy suitable for a particular rearing and finishing enterprise. Buildings represent a major fixed cost in any cattle enterprise and appropriate design considerations offer long term solutions to many environmental issues.

PATHOGENS

Fulton (2009) described the main viral pathogens of BRD as 'the big 4'. They include respiratory syncytial virus (RSV), parainfluenza-3 (PI-3), infectious bovine rhinotracheitis (IBR) and bovine viral diarrhoea virus (BVD). The latter is highly significant as a result of its immunosuppressive effect and consequent amplification of concurrent disease challenge.

Although the above pathogens are potentially well controlled with effective vaccination, a failure to use vaccines appropriately continues to hamper effective control of BRD. Meadows (2010) interviewed 71 farmers who used BVDV vaccine regularly (60 dairy, 11 beef) and reported that:

- For primary booster course 48% administered at an incorrect interval
- 24% followed data sheet recommendations for correct timing of primary dose prior to service
- 34% kept a bottle of BVDV vaccine open over 1 month
- 34% never referred to the data sheet
- 7% chilled the vaccine during transport from veterinary surgery to the farm
- 11% monitored the temperature of the fridge during storage on farm
- 67% made no attempt to keep vaccine cool during administration

Other pathogens are also emerging with increased significance and have either less effective vaccines or no available vaccines. Despite vaccination, outbreak farm E that purchased stock, experienced BRD with associated mortality in growing cattle. The main bacterial causes of BRD are widely reported as *Mannheimia haemolytica*, *Pasteurella multocida, Histophilus somni* and *Mycoplasma spp.* Mycoplasma was diagnosed in outbreak farm E.

Mycoplasma spp. are bacterial pathogens that can play a role in a number of cattle diseases such as BRD, arthritis and mastitis but are often underestimated and less well monitored than other causes (Nicholas 2011). More research has, however, been carried out in recent years to improve detection, diagnosis and control after being identified as a major emerging infectious disease in Europe (Nicholas 2011).

Mycoplasma spp. are not ubiquitous but are wide spread and can be present in the respiratory tracts of non-pneumonic animals with risk implications for purchasing cattle which may be symptomless carriers (Confer 2009). Transmission of infection is via nasal shedding and fomites, which are inanimate objects capable of acting as a reservoir of infection in transmission of a pathogen, such as farm equipment, communal teats, penning divisions and contaminated clothing. The bacteria cannot survive for long outside the host therefore direct, close and repeated contact is usually required (Confer 2009, Nicholas 2011).

Mycoplasma infection can cause mild disease in uncomplicated cases or acute respiratory signs in more severe infections, although infected cattle can also shed and act as reservoirs whilst often appearing clinically healthy (Nicholas, 2011). These animals are often associated with chronic infection and relapse due to unresolved lung lesions (Confer 2009, Nicholas 2011). Their ability to exhibit immunomodulatory behaviour (Caldow 2011, Nicholas 2011) is also significant to their pathogenesis as is their ability to form a true biofilm enhancing colonisation, resistance and possibly accounting for the persistent chronic nature of the disease with outbreaks seen when cells are released to form new colony sites. (Caldow, 2010; Nicholas, 2011).

Many difficulties are therefore encountered in therapy of mycoplasma. There are currently no effective vaccine control measures in the UK and treatment is continually threatened by antimicrobial resistance. *Mycoplasma spp*. have no cell wall therefore penicillins and cephalosporins are not useful in treatment. Some experimental vaccines have shown to exacerbate disease whereas others have shown promise, reducing mortality and treatment cost when given to calves at arrival on farm (Nicholas, 2011). Early recognition and prolonged therapy is therefore currently necessary and a close watch must be kept on antimicrobial resistance as well as continued research into efficacy of vaccines in field studies (Fulton, 2009).

Prompt therapy may help reduce the impact of all these pathogens but long term effects on production are highly significant and a better understanding of biosecurity and supporting immune defences is a vital message to convey in this area. Can we avoid challenge with new pathogens by screening and isolating purchased stock? Can we reduce the impact of such pathogens by supporting effective animal immunity through appropriate nutrition, vaccination and control of BVD?

Limitations of pilot study and further developments:

As a pilot study, it was expected that issues would arise that would limit the quality and quantity of data available for analysis and so conclusions drawn should be viewed in this context. In particular, the concept and inception of the study occurred in the autumn of 2011, already after what is historically the highest risk period for BRD in northern England. Outbreak recruitment opportunities were therefore more limited than would have been

over an entire winter. Some reluctance was also evident in farmers regarding handling of acute BRD animals for sampling and in particular in herds with limited handling facilities. These issues were better controlled in pre-selected baseline herds. Sadly, the death of one farmer mid-study understandably prevented full compliance in data collection by the bereaved family.

Technical limitations in data collection were also challenges: it was difficult to assess humidity and drafts in particular, due to limited performance of commercially available meters (Hesska instruments). There was some limited farmer compliance in re-presenting animals for the second of paired serology samples and some farmer bias was inevitably present – it was challenging to find sufficient proactive outbreak farms willing to participate in the latter part of winter and so recruitment criteria were relatively broad.

CONCLUSIONS

Despite some of the limitations common to many pilot studies, this study has revealed valuable messages regarding the contributing factors to be highlighted from each individual case study and general trends or common findings to be derived from the data gathered, reflecting current occurrences on beef cattle operations in the UK.

Key areas for further investigation and knowledge exchange programmes include:

1. Animal immune status and the influence of nutrition and vaccination technique
2. Environmental management including ridge outlets and ventilation & moisture management
3. Emerging pathogens such as mycoplasma and awareness of purchased stock health risks.

Although this work cannot be extrapolated without further large scale studies and full evaluation, it provides a picture of the potential difficulties encountered at farm level and an insight into the reasons why BRD pathogens may be causing outbreaks within the identified areas of health, buildings, internal environment and management; providing some focus for control programmes. One of the general conclusions derived from the findings of this study is that recommendations are not always being followed. Whether this is through choice, lack of resources, unawareness or lack of understanding is not clear in all cases but in general terms it is likely to be a combination of these. Therefore there is a need for continued knowledge exchange to farmers regarding BRD from a range of industry sources, but delivering a consistent set of messages.

Glossary

AHDB	**Agricultural and Horticultural Development Board**
BRD	**Bovine Respiratory Disease**
BRSV	**Bovine respiratory syncytial virus**
BVD	**Bovine Viral Diarrhoea**
DLWG	**Daily Liveweight Gain**
EBLEX	**English Beef and Lamb Executive**
FCE	**Feed Conversion Efficiency**
Fibrinolytic	**Inflammatory response via fibrin system leading chronically to fibrous tissue production**
GSHPx	**Glutathione peroxidase. An enzyme which protects cells from attack, and which is related to having the correct levels of selenium in the blood**
IBR	**Infectious Bovine Rhinotracheitis**
NADIS	**National Animal Disease Information Service**
NSAID	**Non steroidal anti inflammatory drug**
NYA	**National Youngstock Association**
PI-3	**Parainfluenza 3 virus**
RBC	**Red Blood Cells**
Re-pneumonise	**Repair by air cavities in the lung tissue being re-formed**
RSD	**Respiratory System Disease**
Vasoconstriction	**Constriction of blood vessels**

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Appendix 1: *Reference ranges for animal sampling results tables*

Ranges

Trace element	*Units*	*Reference range*
Copper	(umol/l)	**9-19**
Selenium/Vit E (GSH-Px)	(u/ml RBCs)	**>30**
Cobalt/Vit B12	(pmol/l)	**>100**

Faecal samples	*Units*	*Reference range*
Coccidial ooyctes	(eggs/gram)	**lower limit of detection is 50eggs/gram**
Fluke egg count	(eggs/gram)	**detected or not detected**
Worm egg count (Trichostrongyle-type)	(eggs/gram)	**lower limit of detection is 50eggs/gram**

N.B. RESULTS STATED COLLECTIVELY

Serology	*Negative*	*Inconclusive*	*Positive*
IBR	<0.15	0.15-0.25	**>0.25**
RSV	<0.15	0.15-0.25	**>0.25**
BVD	<0.2	0.2-0.3	**>0.3**
PI3	<0.15	0.15-0.24	**>0.24**
Mycoplasma	<0.25	0.25-0.29	**>0.29**

N.B AN INCREASE OF >0.2 BETWEEN PAIRED SAMPLES IS SIGNIFICANT (SEROCONVERSION)

(Colour code for serology: Positive Seroconversion)

Appendix 2: *Reference ranges for buildings results tables*

Area allowances for cattle

Table 1: Recommended area allowances for beef cattle on solid or bedded courts as per BS5502-40: Optimum environmental conditions for cattle: British Standards Institution (BSI) (2005) BS5502-40, *Buildings and structures for agriculture, Part 40: Code of practice for design and construction of cattle buildings*, London, British Standards Institution

3.0m² or 67kg/m² for a 200kg animal
3.6m² or 83kg/m² for a 300kg animal
4.2m² or 92kg/m² for a 400kg animal
4.6m² or 109kg/m² for a 500kg animal
5.1m² or 118kg/m² for a 600kg animal
5.4m² or 130kg/m² for a 700kg animal

Calculating height factor from inlet and outlet

Using the figure 1. Height from inlet to outlet is measured vertically by measuring from the bottom of the inlet to the bottom of the outlet. Then take this value for 'height outlet to inlet (m)' and read across the horizontal axis, to find the corresponding 'height factor' on the vertical axis.

Calculating height factor – A worked example

Our farm has:

- *A distance of 3.95m from the bottom of the inlet to the bottom of the outlet*
- *Reading across the horizontal axis of figure 1, a height difference of 3.95 m corresponds to a height factor (on the vertical axis of figure 1) of 0.5.*
- *Therefore the height factor for our farm is 0.5*

Calculating ideal outlet and inlet area

For outlet area, first calculate the outlet per animal by reading from the Figure 2. Take the stocking density and read across the horizontal axis. Then read up to the appropriate average kg/head of weight. Read across to the vertical axis. Record the figure **as outlet per animal**.

Then, multiply outlet per animal x height factor x number of animals = **Ideal total outlet area**.

The inlet area should ideally be 4 x the outlet area.

Further details of how to make inlet and outlet calculations can be found in - Dairy Co (2012). 'Dairy Housing a best practice guide'

Calculating ideal outlet and inlet areas – A worked example:

A farm has:

- *132 animals*
- *Floor area of 5 m^2/head*
- *Average weight per animal of 400kg/head*
- *Height factor of 0.5*

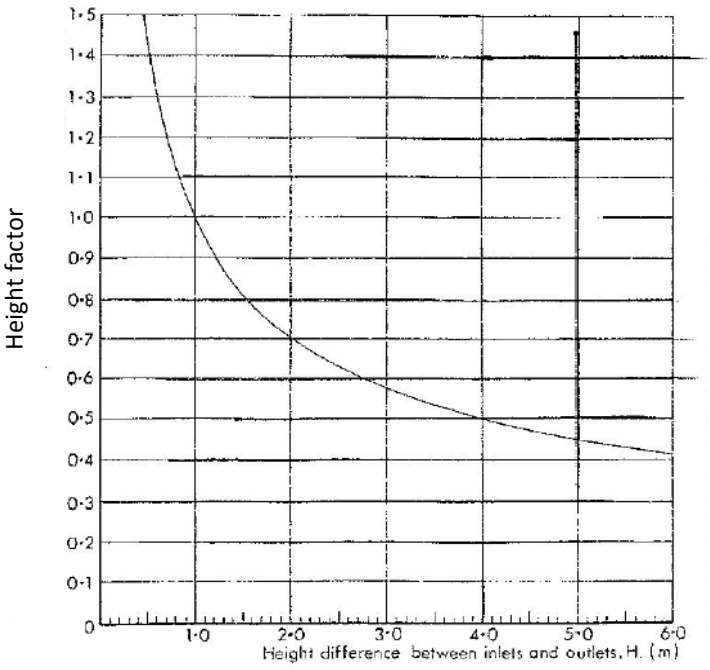
Follow the horizontal axis of Figure 2 to 5m^2/head, then go up to the appropriate line for an average of 400kg/head weight. From that point read across to the vertical axis. This gives us a reading of 0.10m^2 for the ideal outlet per animal.

Multiply this reading, by the height factor, by the total number of animals

0.10 x 0.5 x 132 = ***Ideal outlet area of 6.6m^2***

Multiply this by 4 for the **Ideal inlet area = 26.4m^2**

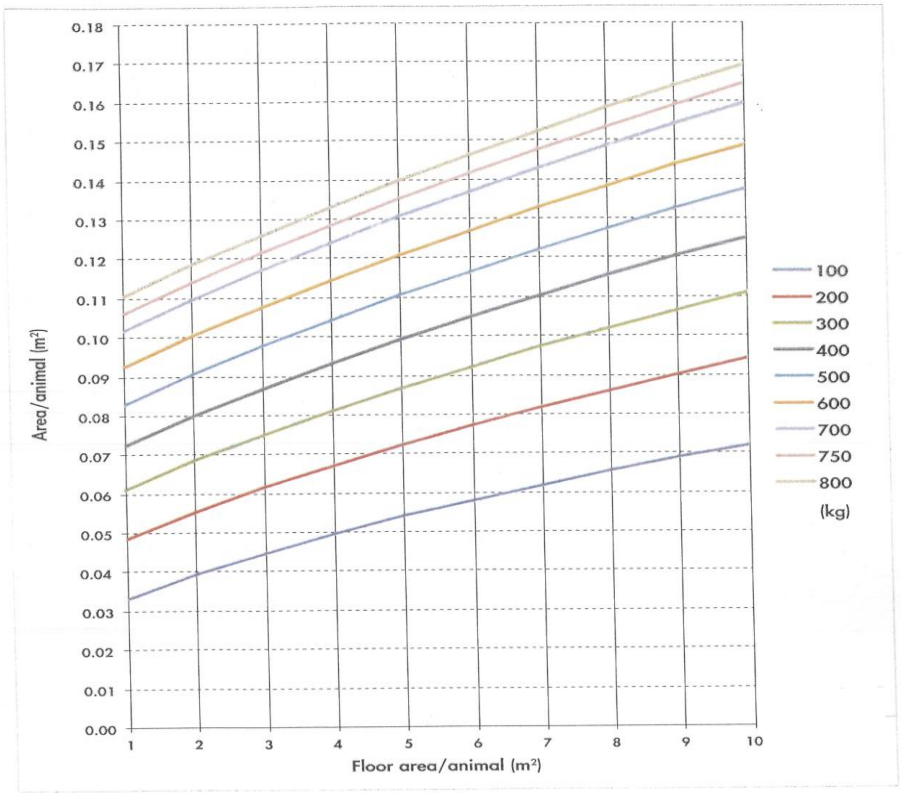
Figure 1: Outlet area calculations – From 'Farm Building Progress (42) October 1975'



Height difference between inlets and outlets (m)

Figure 2: Ventilation areas for cattle buildings

Figure 13.d – Ventilation areas for cattle buildings



Appendix 3: *References for humidity and air speed*

Relative humidity (RH)

With many calf houses the RH is such that viruses can survive for 30 minutes or more, creating a reservoir of virus in the air which means the infection is rapidly spread.

At a RH above 75% many pathogens and viruses can survive for several minutes which increases their spread from animal to animal. However at RH levels below 75% most viruses die relatively quickly after exhalation.

(Hayton, Pocknee & Statham. (2008). *Cattle Rearing to 10 months old (Improving health, welfare and profits)*; Defra/ADAS.)

Air exchange

The overall aim should be to achieve 'fresh air', which means sufficient air exchange, but without draughts. The key practical measures are air speed and smoke clearance.

- Pattern of movement - the smoke from emitter pellets should ideally travel up from animal height and out of outlet areas. If instead it is moving laterally throughout the building, this shows a high risk for transfer of pathogens from one affected animal to an entire group
- Air changes per hour – the rate of clearance crudely indicates how frequently air is being changed in a building. Not only is air space critical but so is the ventilation rate, which is the amount of air replaced within a building in a given time. The aim is a minimum air change within a building of 10 times each hour, increasing in the summer up to around 60 air changes per hour.
- Air speeds above 2m/s, at animal level, are considered to be draughts and are associated with negative effects on animal wellbeing such as suppression of immune function and energy demands. In practical situations an upper threshold of 5m/s is acceptable.

(Hayton, Pocknee & Statham. (2008). *Cattle Rearing to 10 months old (Improving health, welfare and profits)*; Defra/ADAS.)

Upper and lower critical temperatures

The table below shows the thermal comfort zones for cattle and calves. Thermal comfort zones essentially describe the temperatures between which animals are neither heat stressed, nor burning body reserves to maintain their body temperature.

Type of stock	Thermal comfort zones
Adult cattle	3 to 25 degrees centigrade
Calves	7 – 30 degrees centigrade

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