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A six-year study on respiratory viral infections in a bull testing facility

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Abstract

Viral infection dynamics and bovine respiratory disease (BRD) treatment rates were studied over six years at a Swedish bull testing station with an ‘all in, all out’ management system. In August of each of the years 1998–2003, between 149 and 185 4–8-month-old calves arrived at the station from 99 to 124 different beef-breeding herds, and remained until March the following year. Only calves that tested free from bovine viral diarrhoea virus (BVDV) were allowed to enter the station and original animal groups were kept isolated from new cattle in their original herds for three weeks before admission.

Although neither prophylactic antibiotics, nor BRD vaccines were used, less than 0.7–13.2% (mean 5%) of the calves ($n = 970$) required treatment for BRD during the first five weeks following entry. This was probably due, at least in part, to the season (the summer months) when the animals were commingled. In the six-month period August–February, 38% of the animals were treated one or more times for BRD and mortality was 0.7%. Hereford and Aberdeen Angus calves had significantly higher treatment rates than Charolais, Simmental and Blonde d’Aquitaine. Serological testing on samples obtained in August, November and January indicated that bovine parainfluenza virus 3 (PIV-3) infections occurred each year before November after entry. Bovine coronavirus (BCoV) infections also occurred every year, but in 3/6 years this was not until after November. Bovine respiratory syncytial virus (BRSV) infections occurred only every second year and were associated with a treatment peak and one death on one occasion (December). The herd remained BVDV free during the entire study period.

The infection patterns for PIV-3 and BCoV indicated a high level of infectivity amongst bovine calves, whereas the incidence for BRSV was observed at a lower level. Although the rearing of the animals differed from conventional beef production, the study has shown that commingling animals from many sources is not necessarily associated with high morbidity within the first few weeks after arrival. By preventing BRD soon after commingling the prerequisites for protective vaccination at entry might be improved. Applied management routines are discussed.

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Keywords: BRSV; PIV-3; BCoV; BCV; BVDV; Breed; Beef calves; Bovine respiratory disease

1. Introduction

The beef industry suffers large economic losses from infectious diseases and preventive actions are required to improve animal health in fattening units (Smith, 1998). Reducing disease incidence and invoking milder clinical

signs would not only afford animal welfare benefits, but also ultimately reduce the use of antibiotics and minimize the risk of developing resistant microbes (Guillemot, 1999). One major disease complex that impairs animal welfare and requires extensive use of antibiotics, for treatment, metaphylaxis and prophylaxis, is bovine respiratory disease (BRD). Viruses such as bovine respiratory syncytial virus (BRSV), bovine herpes virus 1 (BHV-1), bovine parainfluenza virus 3 (PIV-3) and bovine coronavirus (BCoV)

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are involved in this complex (Kapil and Basaraba, 1997), and often occur in combination with bacteria and mycoplasma (Babiuk et al., 1988). The outcome of each individual case is affected by the animal's previous exposure to the pathogens, by management factors influencing immune responses and infection dose (e.g. colostrum intake, stress, nutritional status, hygiene, ventilation and stock density) and by the treatment. Transient and persistent co-infections with bovine viral diarrhoea virus (BVDV) frequently exacerbate the clinical signs (Potgieter, 1995).

Substantial improvements in animal health have been observed alongside the gradual eradication of BVDV in the Scandinavian countries (de Verdier Klingenberg et al., 1999). Most of the national dairy and beef herds (98.5% and 97.2%, respectively) were declared free of BVDV infection in Sweden in August 2005 (data obtained from the Swedish Dairy Association); however, fattening units in which calves are assembled from many sources are still sometimes affected by BVDV. Although never highly prevalent, BHV-1 was cleared from Scandinavia during the 1990s and only Denmark has had recurrent outbreaks since 1995 (data obtained from Office International des Epizooties, handistatus II). This provides additional advantages for calf rearing compared to countries where BHV-1 is endemic. Nevertheless, BRSV, BCoV and PIV-3 are prevalent and widespread in Sweden (Hägglund et al., 2005), and both BRSV and BCoV cause annual epidemics both in calves and adult cattle (Alenius et al., 1991; Tråvén et al., 1993; Elvander, 1996).

The aim of this paper was to describe management routines, viral infection dynamics and treatment rates in beef calves at a Swedish bull testing station with a high number of animal sources.

2. Materials and methods

2.1. Animals

From 1998–2004, calves at a Swedish bull testing station were monitored for serum antibodies to respiratory viruses. Each year (1998–2003) during the last week of August, between 149 and 185 4–8-month-old (mean 6 months) calves arrived at the station from between 99 and 124 different beef breeding herds. The animals were all tested for antibodies to BVDV and for BVDV isolation and were found to be negative. They passed a clinical examination by a local veterinarian and the original animal group was kept isolated from other cattle during the three weeks prior to admission. The calves were weaned at a minimum of three weeks before departure. Pure bred Charolais, Simmental, Hereford, Aberdeen Angus, Limousin and Blonde d'Aquitaine were represented. A few Highland Cattle were also present during 2002/2003 and 2003/2004.

On arrival at the station, the animals were commingled in two pens generously bedded with straw, in a barn with three walls. They were fed a mixture of silage and grain, ad libitum. Three weeks later, the same area was split into 10 different

pens. Each pen contained 10–20 animals of the same breed and approximate age. The stocking density was 4–6 m² per animal. The same animal carers observed all animals at least twice daily during the six years of the study and weighed them once every second week from October until sale or slaughter the following spring. Since each calf was considered to have a high breeding value, the carers were particularly observant for any changes in the individual health status of the calves (such as demeanour or coughing) and any treatment required was most probably initiated at an early stage.

Mean ambient temperatures were 15 °C in August (summer) and –4 °C in January (winter) between 1961 and 1990, and 17 °C and –4 °C in 2004 (data obtained from the Swedish Meteorological and Hydrological Institute). The stable facilities were left empty between March and August.

A total of 997 animals were included in the study. Treatment data were missing for 27 of these animals, leaving 970 animals included in calculations on treatments. Twenty-three animals that did not remain on the testing facility for the entire study period were excluded from the study (except for mortality calculations, $n = 7$). Two of three animals that were found dead had presented signs of respiratory disease (in September 1998/1999 and December 1999/2000) and one had presented with tympany (October 2003/2004). Four were slaughtered with signs of respiratory disease, poor weight gain or weakness (October 2000/2001, November 2000/2001, November 2002/2003 and October 2003/2004). Sixteen animals were sent home at the owner's request without recorded disease, or were slaughtered due to reproductive/musculoskeletal problems or trauma.

2.2. Sampling and treatments

Samples were collected within the frame of the Swedish control programme against BVDV. Blood samples were collected on arrival at the station (August), in November and by the end of January. During the 1998/1999 and 1999/2000 observation periods, samples from all or almost all animals were collected on these occasions (Table 1). During 2000/2001, 2001/2002, 2002/2003 and 2003/2004, paired sera from fewer individuals were collected (Table 2), except in January, when sera were obtained from all individuals to screen for BVDV antibodies. During 2002/2003 and 2003/2004, samples were additionally obtained in the beginning of October. Moreover, 25 sick animals were sampled during an outbreak of respiratory disease in December 1999/2000 (sera) and 13 animals during an outbreak of mild respiratory disease and diarrhoea in February 2003/2004 (nasal swabs and faeces).

All animals were vaccinated against *Trichophyton verrucosum* and Papillomatosis; vitamins A/D₃/E were parentally administered along with orally administered vitamin E/selenium, pour-on anthelmintics and a magnet. A veterinarian performed clinical examinations of the calves on arrival and additionally when called to a case by the animal carers. The same veterinarian started all treatments throughout the study. Five days of intramuscularly (IM)

Table 1

Serological data for two groups of beef-calves at a bull testing station operating an 'all in–all out' management system

Year	Virus	Number of animals seropositive/number of animals examined ^b (mean corrected optical density ^c)			Seroconversions ^d (month)
		August ^a	November	January	
1998/1999	BRSV	76/167 (0.4) 46%	11/167 (0.3) 7%	7/167 (0.3) 4%	–
	PIV-3	126/167 (0.7) 75%	167/167 (1.2) 100%	167/167 (1.6) 100%	August–November
	BCoV	109/167 (0.4) 65%	167/167 (1.0) 100%	167/167 (1.3) 100%	August–November
1999/2000	BRSV	63/158 (0.5) 40%	20/158 (0.6) 13%	158/158 (1.3) 100%	November–January
	PIV-3	98/158 (0.7) 62%	158/158 (1.1) 100%	158/158 (1.5) 100%	August–November
	BCoV	62/158 (0.7) 39%	156/158 (1.3) 99%	158/158 (1.5) 100%	August–November, November–January

BRSV, bovine respiratory syncytial virus; PIV-3, bovine parainfluenza virus 3; BCoV, bovine coronavirus.

^a Samples were obtained from calves (4–8 months old) on arrival from 99 and 119 Swedish beef-breeding herds in 1998/1999 and 1999/2000, respectively.^b Sera were diluted 1:25 and analysed by indirect ELISA (SVANOVA Biotech). Corrected optical density (COD) values ≥ 0.2 were considered positive.^c Mean COD values of positive samples.^d Seroconversion was defined as a negative COD value converting to a positive in paired sera. No seroconversions detected (–).

Table 2

Serological data on paired samples collected from a selection of individuals in four groups of beef-calves at a bull testing station operating an 'all in–all out' management system

Year	Virus	Number of animals seropositive/number of animals examined ^b (mean corrected optical density ^c)				Seroconversions ^d (month)
		August ^a	October	November	January	
2000/2001	BRSV	3/20 (0.6) 15%	–	–	0/20 0%	–
	PIV-3	5/10 (0.5) 50%	–	10/10 (1.4) 100%	–	August–November
	BCoV	15/30 (0.8) 50%	–	6/30 (0.9) 20%	7/30 (0.8) 23%	November–January
2001/2002	BRSV	4/10 (0.7) 40%	–	1/10 (0.5) 10%	10/10 (1.0) 100%	November–January
	PIV-3	2/10 (1.0) 20%	–	10/10 (0.8) 100%	–	August–November
	BCoV	6/10 (0.5) 60%	–	3/10 (0.9) 30%	10/10 (1.7) 100%	November–January
2002/2003	BRSV	9/20 (1.0) 45%	8/20 (0.6) 40%	4/20 (0.7) 20%	4/20 (0.7) 20%	–
	PIV-3	4/10 (0.5) 40%	3/10 (0.7) 30%	10/10 (0.8) 100%	10/10 (1.3) 100%	August–October, October–January
	BCoV	87/166 (1.0) 52%	160/166 (1.4) 96%	–	–	August–October
2003/2004	BRSV	4/20 (0.6) 20%	20/20 (1.3) 100%	20/20 (1.9) 100%	20/20 (1.9) 100%	August–October
	PIV-3	11/20 (0.8) 55%	19/20 (0.9) 95%	20/20 (1.3) 100%	20/20 (1.4) 100%	August–October, October–November
	BCoV	16/24 (0.8) 67%	–	7/24 (0.8) 29%	7/24 (0.8) 29%	–

BRSV, bovine respiratory syncytial virus; PIV-3, bovine parainfluenza virus 3; BCoV, bovine coronavirus.

^a Samples were obtained from calves (4–8 months old) after commingling of calves from 99–124 beef-breeding herds.^b Sera were diluted 1:25 and analysed in indirect ELISA (SVANOVA Biotech). Corrected optical density (COD) values ≥ 0.2 were considered positive.

Not analysed (–).

^c Mean COD values of positive samples.^d Seroconversion was defined as a negative COD value converting to a positive in paired sera. No seroconversions detected (–).

administrated procaine benzylpenicillin (20 mg/kg, Penovet vet., Boehringer Ingelheim Vetmedica) and a single IM dose of corticosteroids were used when calves showed lethargy in addition to clinical signs of respiratory disease or fever ($>39.5^{\circ}\text{C}$) from undiagnosed disease (both referred to as BRD). When more than 20% of the herd was affected with such signs, the rectal temperature of all individuals was taken, and calves with temperatures $>39.5^{\circ}\text{C}$ were treated. Treatment was repeated for poorly responding cases and the antibiotic changed to danofloxacin 1.25 mg/kg IM for three days (Advocin Vet., Orion), where there was a poor response to the second penicillin treatment. Other diagnoses that required antibiotic treatment (procaine benzylpenicillin), but that are not further considered here, included wound infections and claw inflammation (5 and 60 treatments per 970 animals, respectively). Sick animals were not isolated.

2.3. Antibody and virus detection

Commercially available indirect enzyme-linked immunosorbent assays (ELISAs) were used to detect IgG antibodies specific to BRSV, PIV-3, BCoV and BVDV (SVANOVA Biotech). Sera were diluted 1:25 and analyses performed according to the manufacturers' instructions. Samples that generated a corrected optical density (COD) value of ≥ 0.2 at 450 nm were regarded as positive, as previously described (Niskanen et al., 1989). Seroconversion was defined as a change from a negative to a positive ELISA result, based on COD values, between paired sera.

IgM antibodies to BRSV were detected with an indirect ELISA, as described by Graham et al. (1998). Positive and negative control sera were tested in duplicate and the COD calculated. The COD of each test was then expressed as a percentage of the mean positive COD and the cut-off value was set to 22% (Graham et al., 1998). BVDV virus isolations were attempted on sera inoculated onto fetal bovine turbinate cells, incubated for four days and stained with an immunoperoxidase technique (Meyling, 1984). PCR analyses for BCoV were performed as described elsewhere (Liu, 2004).

2.4. Statistical analysis

Statistical analyses were performed with SAS version 8e (The SAS System for Windows. SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Serological data

PIV-3 infections were observed in all six years of the study. As shown in Tables 1 and 2, all seronegative animals seroconverted against this virus before November each year. Mean COD values of PIV-3 positive samples were mostly lower at arrival, compared to at following sampling occasions (Tables 1 and 2). The percentage of PIV-3 sero-

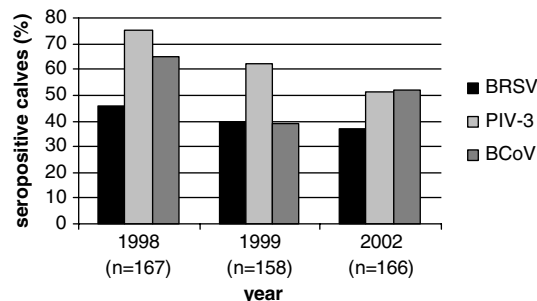


Fig. 1. Percentage of seropositive calves (4–8 months old) with antibodies against bovine respiratory syncytial virus (BRSV), bovine parainfluenza virus 3 (PIV-3) and bovine coronavirus (BCoV) on arrival at a bull testing station from 99 to 119 Swedish beef-breeding herds.

positive calves at arrival was 75%, 62% and 51% in 1998/1999, 1999/2000 and 2002/2003, respectively (Fig. 1). Significantly fewer animals were seropositive to PIV-3 on arrival in 2002/2003, compared to in 1998/1999 ($P \leq 0.01$, χ^2 test).

BCoV infections were also detected in all six years of the study. This virus was circulating in the herd between arrival and November in 1998/1999, 1999/2000 and 2002/2003 and between November and February in 2000/2001 and 2001/2002 (Tables 1 and 2). During 2003/2004, no seroconversions were observed within the study period (between August and November or between November and January), but BCoV infections were confirmed by PCR during an outbreak of mild respiratory disease and diarrhoea in February 2003/2004 (nasal swabs, $n = 8$; faeces, $n = 13$). The percentage of BCoV seropositive calves on arrival was 65%, 39% and 52% in 1998/1999, 1999/2000 and 2002/2003, respectively (Fig. 1). Mean COD values of BCoV positive samples were lower on arrival compared to when seroconversions had occurred (Tables 1 and 2).

BRSV infections occurred only every second year, between November and February in 1999/2000 and 2001/2002 and between arrival and October in 2003/2004 (Tables 1 and 2). All 25 sera that were tested for BRSV-specific IgM in December 1999/2000, during an outbreak of respiratory disease, were positive. The number of seropositive animals, and typically also the mean COD values of BRSV-IgG positive samples, decreased between arrival and the point when seroconversions occurred (Tables 1 and 2). This pattern was also observed in years when BRSV was absent. The percentage of BRSV seropositive calves on arrival was generally lower than for PIV-3 and BCoV (Fig. 1). BVDV infections were not detected in any year. Sera obtained by the end of January from all individuals were BVDV antibody negative throughout the study.

3.2. Treatment rates during five weeks after commingling, August and September

In total, 47/970 calves were treated with antibiotics against BRD during the first five weeks after commingling (5%, range 0.7–13.2%, Fig. 2, August and September).

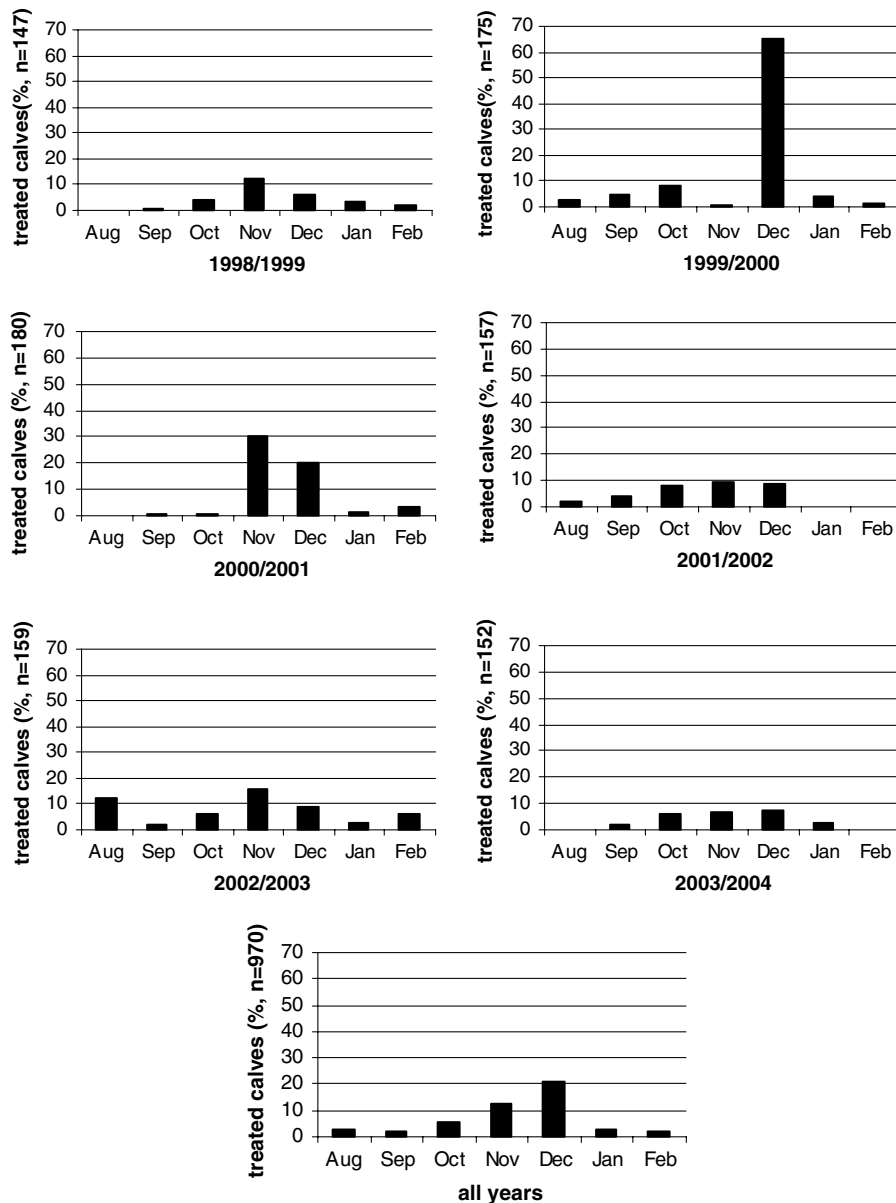


Fig. 2. Percentage of calves treated with antibiotics against BRD. Each year, non-vaccinated BVDV-free calves from 99 to 124 beef-breeding herds were commingled during the last week in August. The facilities were emptied in March.

Only one calf died during this period and no animal was slaughtered or euthanased.

During the last two years of the survey, sera were additionally collected on the 3rd and 2nd October, respectively, to address infections during these five first weeks after entry. A BRD treatment peak of 13.2% in 2002/2003 (August and September) coincided with seroconversions against BCoV and PIV-3. Treatment rates remained low despite BRSV and PIV-3 seroconversions after commingling in 2003/2004 (Fig. 2, Table 2).

3.3. Treatment rates and mortality during the whole test period, August–February

Out of 970 animals included in the study, 407 (42%) were treated with antibiotics once or more during the six months

after entry (August to February). Altogether, 366 calves (38%) were treated against BRD (Table 3), which, quantitatively, was the main diagnosis for antibiotic use (518 treatments vs. 65 treatments against other diseases). Seventy-two animals received two treatments against BRD and 33 animals received more than two treatments against BRD.

Significant differences in treatment rates were observed between the different breeds over the whole test period 1998–2004 ($P < 0.01$, χ^2 test). Hereford (48%) and Aberdeen Angus (55%) differed significantly from Charolais, Simmental and Blonde d'Aquitaine (30–36%), with higher treatment rates (Table 3). As described in Section 2.1, seven animals died or were euthanased due to disease or poor weight gain during the six year period, resulting in an overall mortality of 0.7% (7/977). Four of these calves had presented clinical signs of BRD.

Table 3
Number of calves treated at least once for bovine respiratory disease (BRD) during the six-month period after commingling at a bull testing station

Breed	All years		1998/1999		1999/2000		2000/2001		2001/2002		2002/2003		2003/2004	
	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b	<i>n</i> ^a	BRD ^b
C	474	169 (36)	85	22 (26)	84	62 (74)	84	33 (39)	75	20 (27)	74	22 (30)	72	10 (14)
S	174	53 (30)	12	1 (8)	31	18 (58)	37	10 (27)	33	9 (28)	30	9 (30)	31	6 (19)
He	128	62 (48)	29	5 (17)	24	22 (92)	27	15 (56)	16	6 (38)	19	13 (68)	13	1 (8)
A	71	39 (55)	8	5 (63)	15	10 (67)	11	8 (73)	12	4 (33)	13	8 (62)	12	4 (33)
L	85	31 (36)	9	0 (0)	16	12 (75)	15	9 (60)	16	3 (19)	15	3 (20)	14	4 (29)
B	27	8 (30)	4	0 (0)	5	4 (80)	6	2 (33)	5	1 (20)	2	0 (0)	5	1 (20)
Hi	11	4 (36)	–	–	–	–	–	–	–	–	6	4 (67)	5	0 (0)
Sum	970	366 (38)	147	33 (22)	175	128 (73)	180	77 (43)	157	43 (27)	159	59 (37)	152	26 (17)

Calves arrived from 99–124 Swedish beef-breeding herds.

Breeds: C, Charolais; S, Simmental; He, Hereford; A, Aberdeen Angus; L, Limousine; B, Blonde d'Aquitaine; Hi, Highland cattle.

^a Number of calves included in the study.

^b Number of treated calves. Percentages are given within parentheses.

3.4. Treatment rates and age or serological status on arrival

Taken together, the age on arrival did not differ significantly between treated and untreated calves ($n = 970$, mean age 5.7 vs. 5.8 months on arrival, $P = 0.2$, Student's t test). Charolais calves were studied for correlations between serostatus on arrival and treatment in 1998/1999, 1999/2000 and 2002/2003. Calves seronegative to PIV-3 or BCoV on arrival were at significantly higher risk of treatment against BRD in 1998/1999, but not in 1999/2000 and 2002/2003. BRSV was absent during 1998/1999, and PIV-3 as well as BCoV infections occurred before the end of November. In total, 8% and 14% of PIV-3 and BCoV seropositive animals ($n = 52$, $n = 50$) were treated for BRD in 1998/1999, as compared with 56% and 44% of PIV-3 and BCoV seronegative animals ($n = 32$, $n = 34$). This contrasted with 25% of BRSV seropositive ($n = 40$) and 27% of BRSV seronegative animals ($n = 44$) treated ($P \leq 0.001$ for PIV-3, $P \leq 0.01$ for BCoV and $P > 0.05$ for BRSV, χ^2 test).

Moreover, in 1999/2000 (the year of the clinical BRSV outbreak), BRSV serostatus amongst Charolais was not significantly correlated to higher risk of treatment for BRD. Seventy-three percent of BRSV seropositive ($n = 33$) and 75% of BRSV seronegative animals ($n = 51$) were treated for BRD ($P > 0.05$, χ^2 test). Sixty-seven percent of animals that were BRSV seropositive in November ($n = 9$) were treated for BRD, compared to 75% of BRSV seronegative animals ($n = 75$). However, this difference was not statistically significant ($P > 0.05$, χ^2 test). Calves seropositive to PIV-3 on arrival ($n = 50$) were at higher risk of treatment against BRD in 1999/2000 (82% vs. 61% of seronegative, $n = 34$, $P < 0.05$, χ^2 test), whereas serostatus to BCoV was not significantly correlated with treatment in that year.

4. Discussion

The necessity to source calves from multiple origins appears inevitable in beef rearing in many countries. To

decrease economic losses due to disease and to increase the animal welfare in such systems, management routines for increasing calf health must be thoroughly investigated. Commingling of animals at auctions/buyers, continuous rearing systems, BVDV infections, poor hygiene/ventilation/colostrum-feeding and nutrition are some of the issues that need to be considered. This report describes respiratory virus infection dynamics and BRD treatment rates in a bull testing station with an "all in, all out" management system. Rearing of animals from birth, climatic conditions and duration of transport differ between this herd and conventional European or North-American fattening units; however, the results indicate what is possible to achieve with different management of animals.

Although calves were yearly commingled from around 100 sources and received neither prophylactic antibiotics nor vaccines, treatment rates remained exceptionally low soon after arrival (0.7–13.2% throughout the first five weeks). As reported in a review by Kelly and Janzen (1986), the observed morbidity during the first weeks after arrival at North American feedlots mostly varies between 15–45%, with a peak within the first 21 days. Smith (1998) estimated that 65–80% of the total morbidity in feedlots occurs within the first 45 days and this post-arrival disease peak consists mainly of BRD (Kelly and Janzen, 1986; Smith, 1998). Consistent with these reports, 77% of calves showed BRD within 21 days of arrival at one US feedlot (Hasoksuz et al., 2002) and 25% of 6–9-month-old calves were treated for BRD within 70 days after arrival at a bull testing station in Canada (Durham et al., 1991). BRD treatment rates were on average 20% in 30 Swedish fattening herds during 5–12 weeks of study in continuous systems including animals of 19–216 days of age (Bengtsson and Viring, 2000). High morbidity soon after arrival interferes with the protective effect of vaccination at entry in conventional systems.

Efforts were made to prevent transmission of infectious diseases into the bull testing station in our study. By restricting entry to calves free from BVDV and BHV-1, and by avoiding contact between calves and new animals

from outside the original herds prior to departure, the infection pressure on animals was reduced. An exposure to persistently BVDV infected animals was shown to increase treatment rates against BRD by 43% in feedlots (Loneragan et al., 2005), implying that the prevention of this infection is significant in economic terms. All calves in the study arrived directly from their herd of birth and were thus never exposed to infections at auctions, markets or calf buyers.

It is likely that the season during which calves were commingled affected the prevention of BRSV and BCoV introduction, as well as on other pathogens. The prevalence of most respiratory viral infections is highest during winter (Stott et al., 1980), which is possibly due to stress and overcrowding of individuals in winter housing and increased survival of the virus in the environment (Clark, 1993). In addition to commingling during summertime, the risk of persistent pathogens in the environment between calf groups was reduced because the facilities did not contain animals during the five months before entry.

Efforts were also made to promote the immune system of the bull calves, which were selected by the farmers to be sent for yearly evaluation period at the station. These animals had universally been suckling and grazing and were in good nutritional condition on arrival at the station. Similar to US preconditioning programmes (Speer et al., 2001), animals were weaned prior to departure, thus reducing the immunosuppressive stress encountered during shipping and arrival: anthelmintics and vitamin supplements were also administered. Stable facilities at the bull testing station were well ventilated and generously bedded, and ad lib feeding was provided.

Treatments were almost certainly initiated at early stages of disease because the animals were valuable and carefully observed by the animal carers. This probably increased the treatment rates. However, the overall treatment rate for the whole period (August to February) did not differ from that reported earlier in feedlots (Smith, 1998). The total mortality of 0.7% during six months, in contrast, was lower (Kelly and Janzen, 1986; Smith, 1998). Estimations on feedlot rearing have suggested an average mortality of 2.7 per 1000 animals per month (1.3 of which due to respiratory disease) (Smith, 1998) and mortality rates of 0–15% (mostly 1–5%) during the first weeks after entry (Kelly and Janzen, 1986). Besides environmental and nutritional factors, the lower mortality herein might partly have been due to reduced synergism between pathogens, such as BVDV or BHV-1 (Potgieter, 1995).

Kelly and Janzen (1986) reported treatment rates up to 69% of animals in individual batches and this was also seen during the month of the BRSV outbreak in our study. One option to reduce the impact of such outbreaks would be to use an effective vaccine with durable protection (Howard et al., 1987). The vaccination regime could either be initiated on arrival, or the initial dose given on the farm of origin with the second dose given on arrival. However both the cost of such a strategy and the possible interference of

maternally derived antibodies on the protection induced by BRSV vaccines need to be considered (Hägglund et al., 2004). No BRD vaccines were used in this study because until 2004, no such vaccines were licensed for use in Sweden.

As only a few animals required antibiotics other than penicillin ($n < 10$, data not shown), the resistance pattern of pathogens seemed favourable, assuming that clinical signs of BRD was due to bacterial infection. The treatment results achieved with penicillin vary greatly from data from US and the rest of Europe. β -Lactamase producing *Pasteurella/Mannheimia* spp. has only been detected in a single Swedish fattening herd (Swedish Veterinary Antimicrobial Resistance Monitoring 2003, Swedish National Veterinary Institute) and a nationwide study on antibiotic resistance of BRD pathogens is under progress. The prevalence of *Mycoplasma bovis* in Sweden is not known.

The difference between breeds following BRD treatment was a surprising finding that should be interpreted with caution. We cannot exclude confounding factors, such as the rearing from birth to arrival, the placement/animal density of pens at the station, and the subjective decision of the veterinarian to initiate treatments. However, the serological statuses of calves on arrival did not differ significantly between breeds (data not shown). Other studies have reported significantly higher BRD treatment rates for Hereford calves and, in contrast to the present report, lower for Aberdeen Angus (Durham et al., 1991). Further studies should be designed to study possible genetic differences in disease resistance between breeds.

In contrast to BRSV infections, PIV-3 and BCoV infections were detected each year in the study, and PIV-3 infections were consistently detected in the early autumn. Since the diagnostic approach did not support detection of reinfections, this might merely reflect a higher incidence of PIV-3 in Sweden (Hägglund et al., 2005), which is additionally supported by the higher prevalence of PIV-3 antibody positive animals on arrival at the station. It may also indicate that PIV-3 exhibits a higher transmission rate than the other viruses or is circulating widely during the summer. Interestingly, an earlier onset of PIV-3, compared to BRSV has been observed in British beef-rearing units (Stott et al., 1980).

Both BRSV and BCoV were occasionally detected after commingling in this work. Moreover, birth dates of some calves that were infected before arrival (i.e. those that remained seropositive in years when no animals seroconverted) imply that these infections occur also during the summer months (April–August, $n = 4$, data not shown). These data are in agreement with earlier findings (Verhoeff and van Nieuwstadt, 1984; Hägglund et al., 2005), which suggest that BRSV, PIV-3 and BCoV circulate all year around, although maybe at a lower level during the summer. It is likely that environmental factors influence the severity of disease during infections (e.g. by lower infection dose during the summer due to low virus survival rate in the environment); infections in summer would thus not be diagnosed as often as in winter. Accordingly, the only

clinically observed outbreak of BRSV, with a sharp treatment peak and one death, occurred in December 1999. A neighbouring farm had a BRSV outbreak within the same time period, as confirmed by serology, suggesting that the virus was introduced from outside the herd, possibly by wind, humans or by vectors. During one year when BRSV was absent (1998/1999), seronegativity to PIV-3 and BCoV on arrival was significantly correlated to BRD treatment, supporting earlier data that these viruses also are of clinical importance (Stott et al., 1980; Storz et al., 2000).

With few exceptions, all seronegative animals seroconverted concurrently in the herd. In cases when only a few animals seroconverted, the virus introduction was probably close to the sampling occasion. It is not possible to conclude for how long the viruses continued to circulate in the herd. Virus-specific IgG remained for months in animals that were infected before arrival and were not re-infected during the study period.

5. Conclusion

Although many of the management routines performed in the present study may not be practical in a conventional fattening unit, our results highlight that commingling animals from many different sources is not necessarily associated with high morbidity soon after arrival. By reducing the infection pressure on individuals from BVDV and BHV-1, and often also BRSV, morbidity due to other BRD pathogens was limited during this period. Disease later in this rearing system may be prevented by increasing herd biosecurity after entry or by using effective vaccines at entry. BVDV infections were avoided by virus/antibody detection and quarantine measures.

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