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Bovine viral diarrhoea virus in dairy cattle in New Zealand- studies on its prevalence, biologic and economic impact

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ABSTRACT

The majority (>90%) of dairy cattle will conceive following insemination or natural service, but only about 55% of cattle calve to any single mating. The majority of losses occur before the time of pregnancy recognition and such cattle are generally detected in oestrus and rebred. However, losses do occur after the period of pregnancy recognition resulting in prolonged duration of open periods and increased probability of culling for infertility. Reasons for loss include genetic abnormalities, infectious agents such as Neospora caninum, bovine viral diarrhoea virus (BVDV), and plant toxicities. The incidence, causes and economic impact of pregnancy loss are poorly defined in New Zealand.

In a survey of bulk tank milk, 93% of 141 dairy herds had >10% of cows with BVDV antibody. In another study, 602 herds with a high vs. low bulk tank milk (BTM) BVDV antibody concentration were associated with 1.7% higher annual abortion rates, 2.9d longer calving to conception intervals, 0.04 more services/conception, and 1kg/d reduced solid corrected milk production. Losses due to BVDV were assessed as $90/cow/year in affected herds.

It is concluded that pregnancy loss imposes significant economic costs on the New Zealand dairy industry and that BVDV is likely to be major contributing causative agent. Further research is required to evaluate the effects of BVDV on reproduction in dairy herds, the risk factors for the disease and the cost-benefit of control or eradication strategies.

Keywords: Dairy cattle; Bovine virus diarrhoea virus (BVDV); abortion; embryonic loss; herd reproduction; reproductive performance.

INTRODUCTION

Pregnancy loss in dairy cattle may be attributed to both infectious and non-infectious causes. Late embryo loss has been estimated as about 0.85% per day between 27–42 days post-conception in dairy cattle (Santos et al., 2004). Foetal losses (i.e. from ~42 days post-conception to term) averaged 11% (range 8–22%) in lactating dairy cattle in Europe and the United States of America (Santos et al., 2004). A study in Waikato dairy herds (McDougall et al., 2005) detected the loss of 6.4% of pregnancies from approximately 5 weeks following conception. Pregnancy loss was more common in early compared to late gestation, in cows with clinical mastitis, in those having been previously treated for anoestrous and in cows with short calving to conception intervals.

Bovine viral diarrhoea virus (BVDV) is a pestivirus that causes early pregnancy loss, calf abnormalities, and following mutation to a cytopathic form, the fatal condition of mucosal disease (Brownlie, 2002). Infections with BVDV are widespread in the world, with surveys showing 0-2% of cattle being persistently infected (PI), and 60-90 % of cattle being antibody positive (Houe, 1995). Little data has been published recently on the prevalence or within-herd distribution of BVDV infection in New Zealand dairy cattle, especially reports from representative population-based samples (Thobokwe et al., 2004). Reproductive losses associated with BVDV infection may be the most economically important consequence of this disease (Grooms, 2004). BVDV infection was diagnosed as the cause of abortion in 16% of laboratory submitted cases in a survey of New Zealand dairy herds in the 2001-2002 season (Thobokwe and Heuer, 2004)- second only to abortions due to *Neospora caninum* (35%). The direct production losses and treatment costs of BVDV for an average 50 cow herd in the Maritime provinces of Canada was $2421 dollars/herd, similar to the costs for Johnes disease and neosporosis (Chi et al., 2002). Similar data are not available for New Zealand.

Bulk tank milk (BTM) enzyme-linked immunosorbent assay (ELISA) testing for antibody to BVDV has been used to estimate the proportion of a herd antibody positive to the BVDV (Niskanen, 1993, Beaudeau et al., 2001). This means of testing provides an efficient method of estimating herd BVDV status for use in epidemiological studies, and control and eradication programmes, compared to the high costs of labour and materials with individual animal testing. This report describes two studies using this

methodology which provide population estimates of the prevalence of herds that have been exposed to BVDV, the within-herd prevalence of individual cows exposed to BVDV, and estimate associations between disease status and productivity outcomes.

MATERIALS AND METHODS

Study 1

Data were from a study undertaken in the 2003-2004 dairy season amongst 141 seasonal-supply dairy herds selected from Animal Health Centre, Morrinsville (Waikato) records in March 2004. Herds were selected on the basis that the entire herd had undergone pregnancy testing in the previous 3 months, seasonal calving occurred in spring, herd size was greater than 50 cows, records of the breeding programme were complete, and farmers agreed to participate. Individual cows were defined by pregnancy testing as pregnant after 8 weeks of mating (yes/no) if testing was early enough for this determination, or pregnant by the end of breeding programme (yes/no pregnant). The individual animal records were aggregated to provide proportions at the herd level. Samples for bulk tank milk testing for BVDV antibody were collected using the dairy company routine milk quality testing system. Milk samples were frozen (-20 ^{o}C) prior to being sent to NZ Veterinary Pathology (IVABS, Massey University, Palmerston North), in July 2004, for testing using the Institut Pourquier ELISA BVD/MD/BD P80 Antibody Screening Test for Serum, Plasma and Milk test kit (Institut Pourquier, Montpellier, France). Testing was done according to the manufacturers' recommendations, with two exceptions: the milk sample was centrifuged to provide skim milk for testing, and an extra test result category (60-100% of herd BVDV antibody-positive) was added to the standard 30-100% range following validation work by Gribbles-Alpha Scientific Laboratory (Anna Cross, personal communication). Results were reported as categorical variables i.e. 0-10%, 10-30%, 30-60%, and 60-100% prevalence of antibody positive cows within the herd. Herd reproductive performance was modelled from results of BTM BVDV antibody test results using logistic regression for binomial proportions with correction for overdispersion, and with adjustment for length of the breeding programme (Power analysis prior to conducting the study indicated that finding a statistically significant difference between high and low category herds was unlikely, but the study was still viewed as worthwhile because no population studies had been reported at that time on the prevalence of exposure to BVDV within and between herds).

Study 2

Data were used from a study conducted in 2002 to evaluate the predictive value of level of BVDV antibodies in bulk tank milk for predicting presence of PI animals in 724 dairy herds (Thobokwe and Heuer, 2004). Briefly, a simple random sample of 724 herds from the population of dairy herds in Northland, Waikato and Bay of Plenty regions of New Zealand underwent BVDV bulk tank milk (BTM) antibody testing in March 2002. The results were compared to the antibody status of 15 randomly selected calves in each herd from a sub-sample of 50 herds. Greater than or equal to 5 sero-positive calves per group indicated the presence of one or more persistently infected calves and therefore the herd infection status as likely infected with one or more PI cows (Houe, 1994). Data from that study (Thobokwe et al., 2004) indicated a cut-point of ≥80% inhibition (%INH) of BTM BVDV-antibody levels as defining herd current infection status as positive (presence of ≥ 1 PI animal in herd). Information on individual cow calving, breeding and milk test records for the 2001-2002 season, calving records in the 2002-2003 season, and removals in both seasons were retrieved from the Livestock Improvement Corporation (Hamilton) database.

Gestations were calculated as the difference between the last mating date in the 2001/02 season and the calving date in the subsequent season, and where no calving descriptor was recorded, defined as normal (270-300 days), induced (220-270 days), or due to abortion (63-220 days). Using these definitions, induced calvings were likely under-reported and estimated as an unrealistic <0.2% of calvings, but this figure was not used for other calculations. Gestations calculated as >300 days were given an assumed last mating date as calving date less 282 days. Animals with no calving date in the subsequent season and recorded as culled or sold due to infertility were considered as not pregnant. The calving to conception interval was calculated as the difference between the calving date and the last mating date in the season 2001/02. For animals which had a gestation period longer than 300 days and no stated pregnancy outcome in the LIC database, a mating date was assumed as before and used for the calving-conception interval calculation. Only the interval between the first and second service was considered since later intervals were regarded as unreliable. Service intervals of 18–24 and 38–46 days were defined as physiological (normal inter-oestrous interval or multiple of two normal intervals), and intervals of 25–37 or >46 days as non-physiological. Intervals <18 days were excluded from the analysis due to the possibility of

repeated artificial insemination within the same oestrus cycle. A milk production model was developed to compute a milk production parameter that was comparable between herds using Wood's equation and estimated mean values were generated for each herd for a 3-year old cow being 100 days in milk (age=3, DIM=100). Herd BVDV antibody (%INH) was converted to a 6 category ordinal variable (<40%INH, 41-50%INH, 51-60%INH, 61-70%INH, 71-80%INH and >80%INH). Descriptive statistics were calculated for all variables of interest including the number and range of herds in each category. The relationship between the response of interest and herd BVDV antibody class (1-6) was assessed using a multivariate regression model. Herd size, average cow age, breed types and region were included in the model as covariates to control for confounding effects due to these variables. Adjusted means (geometric means for SCC) and confidence intervals were computed as least square means (LSM) and compared between each of the six groups of BTM antibody against BVDV after correction for multiple comparisons in general linear models. An estimate of the economic cost associated with BTM BVDV antibody test levels >80% INH was made using data from study and industry statistics (Anon, 2004)

RESULTS

Study 1

Tests for BVDV on BTM samples from 141 herds consisting of 38,105 cows showed that 7%, 33%, 45% and 14% of herds had 0 to 10%, 10 to 30%, 30 to 60% and 60 to 100%, respectively, of cows within those herds with antibody to BVDV indicating previous infection. Thus, 93% of study herds had evidence of previous infection with BVDV. Herd reproductive performance declined numerically with increasing within-herd prevalence of BVDV antibody positive cows, but the

differences were not statistically significant. Estimated means of reproductive performance with 95% confidence intervals for each BVDV category are shown in Figure 1.

FIGURE 1: Adjusted mean with 95% confidence intervals for herd in-calf percentage after 8 weeks of breeding (a) and final herd not in-calf percentage (b) for each category of within-herd prevalence of BVDV antibody-positive cows.
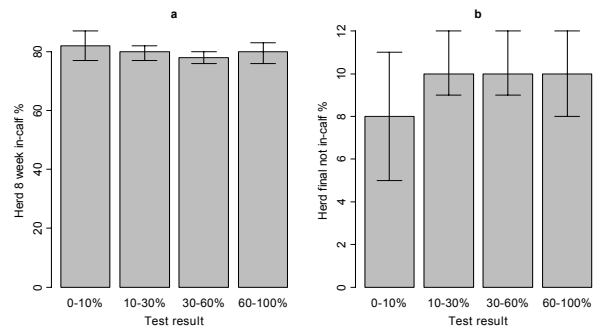
Study 2

For each of the six BVDV BTM-antibody classes for herd size, region and breed composition, least square means (±standard errors) are shown in Table 1. The number of services per conception and the time from calving to conception increased significantly leading to an approximate increase of 3 days to conception. Abortion rates increased almost two-fold from 1.9% to 3.4% when the level of BVDV antibody in BTM was higher than 60%INH. Milk production was about 0.5kg/d lower in herds with >80%INH of BVDV antibody in BTM than in herds with lower antibody concentration. However, not all performance indicators were associated with the level of BVDV antibody in bulk tank milk in this study (rate of physiological returns, first service conception rate, annual pregnancy rate, culling rates and mean somatic cell counts.

TABLE 1: Measures of herd reproduction and production (adjusted means ± standard errors) for each Bovine Viral Diarrhoea Virus bulk tank milk antibody test result category.

		BVDV BTM Antibody % Inhibition					
	N	<40	41-50	51-60	61-70	71-80	>80
% of service returns at physiological interval[1]	463	89.9 ± 0.9	90.5 ± 0.7	90.9 ± 0.6	91.0 ± 0.6	92.4 ± 0.6	90.8 ± 0.8
First service conception rate (%)	552	53.4 ± 1.6	54.5 ± 1.1	53.5 ± 1.0	52.0 ± 1.1	52.3 ± 1.1	52.8 ± 1.4
Number of services per conception	560	1.38±0.03	1.38±0.02	1.38±0.02	1.39±0.02	1.40±0.02	**1.42**±0.03
Interval calving-conception (d)	528	87.2 ± 0.9	87.3 ± 0.7	88.1 ± 0.6	87.0 ± 0.6	88.0 ± 0.7	**90.1****± 0.9
Annual pregnancy rate (%)	544	93.0 ± 0.7	94.5 ± 0.5	94.0 ± 0.4	93.5 ± 0.5	94.0 ± 0.5	94.0 ± 0.6
Annual abortion rate (%)	544	1.6 ± 0.9	2.2 ± 0.7	1.9 ± 0.6	**3.3****± 0.6	**3.5****± 0.6	**3.3****± 0.8
Annual infertility culling rate (%)	557	9.5 ± 0.9	8.5 ± 0.7	10.2 ± 0.6	9.2 ± 0.6	9.0 ± 0.6	8.2 ± 0.8
Overall annual culling rate (%)	557	22.7 ± 1.4	22.6 ± 1.0	23.3 ± 0.9	22.0 ± 0.9	21.1 ± 1.0	22.1 ± 1.2
Mean somatic cell counts[2]	517	84.8±10.0	87.3±7.2	92.6±7.0	100.1±7.8	93.6±7.5	89.6±9.2
Adjusted standard milk/day production[3]	522	16.8 ± 0.4	17.1 ± 0.3	17.2 ± 0.2	17.0 ± 0.3	17.5 ± 0.3	**16.2****± 0.3

* P <0.05, ** p<0.01 compared to others on same row
[1] Return to service recorded at 18-24 or 38-46 days (normal inter-oestrous interval or its multiple)
[2] Mean ± 95% confidence limits of geometric mean
[3] Adjusted for days in milk and percent fat and protein

The gross economic loss associated with PI-positive herds (>80%INH) and in the NZ population of dairy herds was estimated from study data (Table 2). According to our figures, the largest loss component in affected herds was due to increased abortion and time to conception ($14,000/300-cow herd and year) followed by milk production decline ($12,000) and calf loss ($1,200). The total annual loss is estimated at $27,000 per year for a herd of 300 cows with one or more PI animals. Given that 17% of all herds in the three study regions have one or more PI cows, and if it is assumed that this is similar in all regions of New Zealand, the estimated loss to the dairy industry in amounts to approximately $58.9 million every year.

DISCUSSION

Study 1 found the majority (>90%) of study herds tested positive for the presence of BVDV antibody in bulk tank milk. This supports the findings of Thobokwe et al (2004) from a random selection of 724 New Zealand dairy herds using the same test. The current study did not find significant associations between BTM BVDV antibody status and 8 week in-calf proportion or final non-pregnant proportion. This does not imply that there is no association between BVDV and reproductive performance at the herd level in the study population because statistical power was limited to find a difference (a difference in final non-pregnancy rate of >16% could have been detected with the available number of herds). The presence of confounders such as variation in oestrous detection efficiency, nutritional and other management decisions mean that large number of herds and detailed data collection for possible confounders would be required to detect any effect of BVDV on reproductive performance. These outcome variables (8 week in-calf proportion or final non-pregnant proportion) may also be relatively insensitive measures of any impact of BVDV on reproductive performance. It is also possible that BTM BVDV antibody level is not directly causally associated with herd reproductive performance, but this study design could not test that hypothesis at the individual cow level.

The results from Study 2 showed that the BVDV antibody concentrations of BTM correlated with reproductive and production performance, predominantly in the group of herds with >80%INH. This was the group that showed a close relationship between BTM antibody and antibody prevalence in calf mobs (Houe, 1994). The number of services per conception and the time from calving to conception increased probably as a result of fertilization failure or embryo loss (Grahn et al., 1984, McGowan et al., 1993). Herds experiencing natural infection with BVDV have been found to have increased number of abortions (Larsson et al., 1994). A sudden reduction in milk yield has been described from individual herd disease outbreaks (Barber et al., 1985, Larsson et al., 1994) Moerman et al. (1994) found a significant reduction in milk yield experienced in cows seroconverting to BVDV compared to herd-mates that did not seroconvert. Thus, immunosuppression followed by an increase in clinical mastitis (Cai et al., 1994) and feed energy utilised for immune-function, both initiated by BVDV infection are plausible causes to explain the observed milk production decline.

TABLE 2: Estimated economic loss associated with high bulk tank milk Bovine Viral Diarrhoea Virus antibody test result category (>80% inhibition) at herd and industry levels (for example herd of 300 cows, average 1.2 kg MS/cow/d for season, $4/kg MS payment).

Factor of loss associated with BVDV	Estimated loss
Fertility	+3d/cow to conception x 300 cows x 1.2 kg MS/cow/d x $4/kgMS = $4,320
Production	-0.04 kgMS/d x 250 days x 300 cows x $4/kgMS = $12,000
Abortion	+4% x 300 cows x $800 RPO = $9,600
Calf	-4% calves born alive x 300 cows x $100 = $1,200
Total loss for an affected herd	$27,120 per year or $90/cow/year
Population prevalence of PI-positive herds	17%
Estimated loss for the dairy industry (NZ)	17% x 12,751[1] herds x 302 cows/herd[1] x $90/cow = $58.9 million

[1] Dairy Statistics 2003-2004, Livestock Improvement Corporation, Hamilton.

The rate of physiological service intervals was analysed because BVDV is known to cause early embryonic death leading to return to oestrus at non-physiological intervals (McGowan et al., 1993) but our data did not show an association with BVDV antibody in BTM, possibly because such an effect is too rare to be significant at population level. The first service conception rate was expected to decrease with increasing BVDV antibody because in vivo studies have demonstrated fertilization failure as a primary cause of reduced conception rates (Grahn et al., 1984). However, this effect was not observed in this study, again possibly due only a small proportion of the herd being infected at the time of fertilisation. The annual pregnancy rate is the result of reproductive performance, culling and involves repeat breeding. All these factors contribute to the final reproductive outcome, thus a BVDV effect could not realistically be significant in the data available. Similarly, the culling rates were unaffected since only about 40% of the cull-cows were removed due to reproductive failure.

Exposure to BVDV infection is likely to be common amongst dairy cows in herds throughout NZ. However, any impact of infection in adult cows may be subtle and difficult to quantify. Nonetheless, BVDV was significantly associated with herd reproductive performance and milk production, and may be associated with substantial economic loss in dairy herds in the northern regions of N.Z due to increased abortion rates, extended calving to conception intervals and reduced milk production. This effect may be similar in other regions of New Zealand.

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