Risk factors for pre-weaning calf morbidity and mortality due to farmer-diagnosed diarrhoea on 49 New Zealand dairy farms

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Diarrhoea is the most commonly reported calf disease and a major cause of calf morbidity and mortality worldwide (Gitau et al. 1994, Bendali et al. 1999, Bazeley 2003, Svensson et al. 2006, Millemann 2009, Marce et al. 2010). The average within-herd incidence of diarrhoea in pre-weaning calves is around 20%, varying between 0 and 70% worldwide (Bendali et al. 1999). The economic implications of calf diarrhoea include calf losses, treatment costs, time costs and reduced liveweight gain (Lorenz et al. 2009) and, despite numerous studies on risk factors and prevention worldwide, costs of calf diarrhoea remain high, compared to other diseases on-farm (Younis et al. 2009).

Risk factors have been well documented in Europe and the UK as catalysts for calf diarrhoea in dairy herds (Bendali et al. 1999, Bazeley 2003). New Zealand dairy farming systems have been less well examined and the literature is limited. The current study outlines the major risk factors for calf diarrhoea, based predominately on international research, and then focuses on the identification of risk factors for pre-weaning calf diarrhoea in the New Zealand context, with a view to offering some concrete advice to farmers for prevention and control.

The specific aim of this study was to provide an estimate of and identify risk factors for farm-level pre-weaning calf morbidity and mortality due to diarrhoea and describe treatment(s) for pre-weaning calf diarrhoea, currently used by herd owners in pasture-based spring management systems in the Waikato region of New Zealand.

Materials and methods
Calf-rearers on 49 Waikato dairy farms provided information via a prospective interview survey regarding their calf-rearing practices. Farmers were selected using a random number generator and interviewed before the start of the calving season. The mortality and morbidity data was collected in a separate farm visit after the completion of calving.

Case definition of pre-weaning calf diarrhoea
Diarrhoea is defined as ‘a rapid movement of fluids through the intestine resulting in poor absorption of water, nutritive elements and electrolytes’ (Parkinson et al. 2010).

Within this study ‘diarrhoea’ could take a variety of forms (i.e. consistency ‘custard like’ to ‘watery’) and could have been of any aetiology in calves from birth to weaning.

Incidence of morbidity and mortality due to pre-weaning calf diarrhoea
Incidence risk was defined as the number of new cases in a cohort during a defined time period divided by the total number ‘at risk’ at the beginning of the time period. The incidence rate was the number of new cases in a cohort during a defined time period divided by the total ‘animal time at risk’ during that time period.

‘Morbidity risk’ was defined as the number of calf diarrhoea cases during the spring calving period (1st July to 30th September) divided by the total number of calves ‘at risk’ at the beginning of the time period. ‘Mortality
risk’ was defined as the number of calves that died from calf diarrhoea divided by the total number of calves ‘at
risk’ at the beginning of the time period.

Forty-five farmers (91.8%) provided data allowing the calculation of calf morbidity and mortality risk due to
diarrhoea from the 1 July 2010 to 30 September 2010. Associations between management factors and farm-level
calf morbidity and mortality risk due to diarrhoea were examined using univariable and multivariable analysis.
Binomial logistic regression models were built for the mortality and morbidity data.

Risk factors were examined at the herd-level. The outcomes of interest were:
• within-herd calf morbidity risk due to diarrhoea; and
• within-herd calf mortality secondary to diarrhoea.

Results
The morbidity risk for replacement calves was 9.95% (95% CI=6.34%-13.56%) and the mortality risk
for replacement calves was 1.02% (95% CI=0.46%-1.58%), with a case fatality risk of 11.92% (95%
CI=4.60%-19.24%).

The morbidity risk for bobby calves was 1.10% (95% CI=0.54%-1.66%) and the mortality risk for bobby calves
was 0.32% (95% CI=0.12%-0.52%), with a case fatality risk of 23.97% (95% CI=9.07%-38.87%).

Figures 1 and 2 show the farmer-diagnosed within-herd calf morbidity risk and calf mortality risk respectively,
due to diarrhoea on 45 Waikato dairy farms in the 2010 season.

An increased morbidity risk in replacement calves was associated with the isolation of calves with diarrhoea
in a different shed ($p$-value<0.01) and feeding of sick calves last ($p$-value<0.01). Morbidity risk was negatively
associated with the use of biosecurity measures ($p$-value=0.02), an increasing age at which calves were first
fed once a day ($p$-value<0.01), changing the number of teats per calf ($p$-value<0.01) and increasing herd size
($p$-value<0.01). Morbidity risk of replacement calves was also negatively associated with herd vaccination with
rotavirus and/or salmonella vaccines ($p$-value<0.01).
An increasing age (more than three weeks) at which calves were changed to once a day feeding (p-value<0.01), water offered in the calf sheds (p-value<0.01) and bedding replacement in the calf sheds (p-value<0.01) all reduced the odds of replacement calf mortality.

Bobby calf morbidity was associated with the use of navel spray (p-value=0.09), isolation of sick calves in a different shed (p-value=0.07) and increasing numbers of calf rearers (p-value=0.01). Increasing herd size reduced the odds of bobby calf morbidity due to diarrhoea (p-value<0.01).

Changing water in the calf sheds regularly (p-value<0.01), rearing bobby calves separately (p-value<0.01) and feeding sick calves last (p-value<0.01) reduced the odds of bobby calf mortality.

Of the farmers who reported diarrhoeic calves, 81.6% used electrolyte therapy and 57.9% used antibiotics, either alone or in combination with electrolytes. Of the farmers which used antibiotics, 34.7% used oral, while 65.3% used injectable antibiotics.

Discussion

Importance of calf diarrhoea—economic and zoonotic implications

As approximately one-third of the cost of rearing a calf from birth to first calving is incurred during the first 12 weeks of rearing (Schouten 2003), calfhood diseases have a major impact on the economic viability of cattle operations, due to direct costs of calf losses, treatments and the long-term effects on performance (Donovan et al. 1998, Millemann et al. 2009, Lorenz et al. 2011). The average cost associated with the treatment, prevention and mortality of gastrointestinal disease has been reported to be US$33.46 per calf per year (Bendali et al. 1999). Data from a 1975 study conducted in the United States suggested that enteric pathogens kill up to 25% of calves per year, resulting in US$250 million in losses (Frank and Kaneene 1993). It is likely that costs associated with calf diarrhoea have increased in the last 35 years. Diarrhoea in calves less than 30 days of age is difficult to prevent as it is multifactorial, both in relation to aetiological agent and risk factors associated with management.

In addition to its economic impact, calf diarrhoea is important because of its public health implications. Many of the organisms causing diarrhoea in calves, including Salmonella and Cryptosporidia species, are zoonotic and humans with impaired immune function are especially at risk of contracting disease (Vermunt 2002, Lund et al. 2011). Enterotoxigenic E.coli is a significant cause of diarrhoea among children and travellers in the developing world (Younis et al. 2009). As farmers attempt to control diarrhoea in their calves through the administration of antibiotic-based treatments, there are also developing issues around antibiotic residues in food producing animals (Frank and Kaneene 1993, Dey et al. 2003), which may have further public health implications.

Limitations of the study design

Although the farmers that participated in the study were randomly selected, there was an element of voluntary participation. This meant that farms selected to participate may have been managed and run by motivated farmers who were more interested in productivity and in their animals’ welfare than the average New Zealand dairy farmer.

The current study data should not be over-interpreted due to the relatively small sample size, with 45 farms analysed for morbidity and mortality risk.

Moreover, there may have been under-reporting of the number of calves observed with diarrhoea; possibly due to a lack of time during the busy spring period, unfavourable weather conditions or apathy. Over-reporting is unlikely to have been a problem in this study.

This was a prospective study, as participants were asked to complete a questionnaire prior to the calving season. Thus, the temporal relationship between the risk factors and disease occurrence are in the correct sequence. However, the management practices that the farmers said they were going to implement were not verified due to time constraints.

Additionally, some of the answers may have been biased by what the farmer thought was the ‘correct’ answer to the question, rather than being reflective of actual management practices on-farm. An attempt was made to minimise bias by employing a face-to-face interview technique. There may have been some interview bias introduced to the study since the face-to-face interviews were conducted by two different people.
The total number of calves in the population was estimated, by herd, based on the number of cows and heifers to calve provided in the questionnaire. This approach to estimating the total calf population could have introduced a source of bias as no direct measure of the number of calves born was undertaken. Moreover, there was no consideration given to animals which may have produced twins and/or lost a calf through late-stage abortion, stillbirth or dystocia. Therefore, the calf morbidity and mortality risk due to diarrhoea may be higher than what has been measured in this study.

**Comparing morbidity and mortality risks with international studies**

In a previous study, the incidence risk of morbidity (‘morbidity risk’) due to diarrhoea in calves less than 30 days of age was found to be between 15.0% and 20.0%, while the incidence risk of mortality (‘mortality risk’) secondary to diarrhoea in pre-weaning calves varied between 1.5% and 8.0% (Lorino *et al.* 2005).

Sivula *et al.* (1995) reported a morbidity rate due to enteritis of 0.15 cases per calf days at risk, with a mortality risk secondary to diarrhoea of 17.9%. The incidence of calf enteritis in a 1982 study (Blom *et al.*) was 10.6%, while Curtis *et al.* (1988) noted a 9.9% crude morbidity risk from diarrhoea between birth and 14 days of life. In comparison, Waltner-Toews (1986) reported a substantially higher morbidity risk between birth and weaning of 20.5%. Two Swedish studies (Svensson *et al.* 2003 and 2006) reported a morbidity rate of 0.035 cases per calf month at risk and morbidity risk due to calf diarrhoea of 2.7%.

Gitau *et al.* (1994) showed a crude calf morbidity and mortality risk of 27% and 22% per year respectively, where diarrhoea was the most common cause. This was similar to a crude mortality risk documented by Perez *et al.* (1990) at 24.6% and a study in 2010 (Bartels *et al.*) that reported 19.1% of calves with diarrhoea and 23.8% of calves with ‘custard like’ faeces.

The estimates of morbidity and mortality from this study were lower than those reported from previous international studies. The lower morbidity and mortality risks reported here may be due to the significant differences in calf management systems found in New Zealand relative to other international dairy industries.

**Risk factors for calf diarrhoea developed into a veterinary resource**

Worldwide, there have been numerous studies conducted on risk factors for development of calf diarrhoea in dairy and beef herds (Perez *et al.* 1989, Frank and Kaneene 1993, Gitau *et al.* 1994, Bendali *et al.* 1999, Bazeley 2003, Svensson *et al.* 2003 and 2006). However, although a number of different risk factors have been identified as significant, the external validity of these results (i.e. the validity of extrapolating results to other populations) is problematic, due to differences in data analysis and statistical approaches (Silverlas *et al.* 2009).

Identification and prioritisation of the relevant risk factors associated with calf diarrhoea, in conjunction with a clinical diagnosis of the aetiological agent, may allow accurate advice to be given to farmers in order to help control this insidious condition. It is intended that this will result in substantial improvements in the welfare of calves, whilst providing economic benefits to the farmer. There may also be public health benefits.

The risk factors explored in this first New Zealand based study were compiled into a risk factor sheet, which was designed to be use by veterinary clinicians pre-calving with their clients. Farms with a high risk of developing calf diarrhoea could then be targeted to try to change management strategies and prevent disease.

The principles of preventing calf diarrhoea are aimed at either minimising the infectious pressure and/or at boosting the calf’s immunity and resistance to disease (Bazeley 2003). However, the multifactorial nature of calf diarrhoea makes separation of the individual effects of different management factors challenging (Schuman *et al.* 1990, Bendali *et al.* 1999) and advice to farmers should take this into account (Crouch *et al.* 2001, Younis *et al.* 2009).

**Conclusions**

The morbidity and mortality risk of pre-weaning replacement calf diarrhoea was 9.95% (95% CI=6.34%-13.56%) and 1.02% (95% CI=0.46%-1.58%) respectively, from 45 spring-calving herds in the Waikato region of New Zealand.

The morbidity and mortality risk for bobby calves was 1.10% (95% CI=0.54%-1.66%) and 0.32% (95% CI=0.12%-0.52%) respectively, with a case fatality risk of 23.97% (95% CI=9.07%-38.87%).
A number of hygiene, biosecurity and feeding management practices were associated with the presence and risk of diarrhoea and deaths secondary to diarrhoea. While the current study design does not indicate causality, the data suggests that attention to management practices may reduce the incidence of calf diarrhoea in New Zealand dairy herds.

"The full text article is intended to be published in New Zealand Veterinary Journal later this year.

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