



SHORT COMMUNICATION

Prevalence of failure of passive immunity transfer in Australian non-replacement dairy calves

N Roadknight,^{a,b,*} E Jongman,^{a,b} P Mansell,^b N Courtman,^b D McGill,^b G Hepworth^c and A Fisher^{a,b}

Failure of passive immunity transfer (FPIT) increases the risk of morbidity and mortality in dairy calves. The prevalence of FPIT in dairy calves has generally been reported to be high, with FPIT estimated to occur in 38%–42% of Australian dairy calves. However, the focus of previous studies has been on replacement heifer calves. Our aim was to assess the prevalence of FPIT in Victorian bobby calves (non-replacement dairy calves). We collected blood samples from 3608 bobby calves at three abattoirs at exsanguination, and measured serum total protein as an indicator of passive transfer. We found that 36% of bobby calves showed evidence of FPIT (serum total protein ≤ 52 g/L), and 50% of calves had poor or fair passive transfer (< 58 g/L). When a subset of calves (from farms with more than five calves in the dataset) was analysed using a linear mixed model, Jersey calves and crossbred/other calves had an estimated 5.3 g/L and 5.1 g/L higher serum total protein concentration, respectively, than Holstein-Friesian calves ($P < 0.001$). Our results suggest that the prevalence of FPIT in bobby calves at abattoirs is similar to that reported in dairy heifer calves sampled on farms. A high prevalence of FPIT has implications for bobby calf morbidity and mortality, as well as calf viability and profitability for dairy-beef production.

Keywords bobby calf; colostrum; dairy veal; serum total protein; welfare

Aust Vet J 2022;100:292–295

doi: 10.1111/avj.13160

Failure of passive transfer of immunity (FPIT) has the potential to be a calf health and welfare issue, as it increases the risk of morbidity and mortality.^{1, 2} Previous research has estimated that FPIT occurs in 38%–42% of dairy calves on Australian farms, as determined by low serum immunoglobulin G or total protein.^{3, 4} However, most studies have focussed on replacement heifer calves. Bobby (or bob veal) calves are non-replacement dairy calves that are unweaned and separated from their mother. Data from the Dairy Australia Animal Husbandry Survey 2019 indicate that 94% of bobby calves originating from Victoria and the Murray dairy regions are 7 days old or less when they are transported off farm (Dairy Australia, unpublished data).

*Corresponding author. Email: nroadknight@gmail.com^aAnimal Welfare Science Centre, The University of Melbourne, Corner Flemington Road and Park Drive, Parkville, Victoria, Australia; nroadknight@gmail.com^bFaculty of Veterinary and Agricultural Sciences, The University of Melbourne, 250 Princes Highway, Werribee, Victoria, Australia^cStatistical Consulting Centre, The University of Melbourne, 139 Barry Street, Carlton, Victoria, Australia

Bull calves, which make up a large proportion of bobby calves in Australia, have been reported to be more than twice as likely as heifers to have agammaglobulinaemia (serum total protein < 40 g/L).³ Replacement heifer calves may be given priority management, including colostrum management,³ compared with bobby calves, because heifer calves are the future breeding and producing stock for dairy farms.

Young non-replacement dairy calves with FPIT have been reported to be more likely to develop a depressed attitude following transport,⁵ and dairy heifers with FPIT are at higher risk of morbidity and mortality prior to weaning.² FPIT in bobby calves could therefore lead to an increased risk of welfare compromise between birth and slaughter, and, if calves were diverted into a dairy-beef system, FPIT could increase the risk of morbidity and mortality prior to weaning. The aim of this study was to estimate the prevalence of FPIT in bobby calves using serum total protein measurements; a high prevalence of FPIT would have implications both for calf welfare and for dairy veal and beef productivity. We expected FPIT prevalence to be higher in bobby calves than previous estimates of FPIT in heifers, due to the higher value of replacement heifers in the dairy industry.

Blood samples were collected and processed from 3608 bobby calves from three commercial abattoirs in Victoria, Australia, over 45 days between August 2017 and April 2018, as described in Roadknight et al.⁶ In brief, calves were handled, stunned and slaughtered by abattoir staff as per normal abattoir practices. Stunning was achieved through electrical head-only stunning and was followed by cervical cutting and thoracic sticking. Samples were collected at exsanguination by uncapping a Vacuette® (Greiner Bio-One, Kremsmünster, Austria) 8 mL serum separator clot activator tube, and collecting blood mid-stream from the cervical cut or thoracic stick site. Samples were then placed into a container cooled by icepacks, and centrifuged at 2500 g for 5 min within approximately 10 h of collection. Serum was transferred to plain tubes and frozen on the day of collection at -20°C until analysis. Serum was thawed within 7 months of being frozen and analysed for total protein (Total Protein Gen.2 [colorimetric biuret]; Roche, Switzerland) with a Cobas Integra® 400 Plus biochemistry analyser (Roche, Switzerland).

During exsanguination, National Livestock Identification System radio frequency identification ear tags were scanned, and external numbers were read aloud into a voice recorder. This allowed each calf and the farm of origin to be uniquely identified. Time between loading for transport at the farm and slaughter were calculated based on ear tag time stamps, as described in Roadknight et al.⁶ Calf sex was assessed based on external genitalia, and breed was assessed

based on phenotype as either Holstein-Friesian, Jersey or crossbreed/other breed.

In order to explore the effect of farm and breed on total protein, linear mixed models were fitted for a subset of calves that were from farms that had supplied more than five calves to the dataset. Models were run using the “lme4” and “lmerTest” packages in R version 4.0.3,⁷⁻⁹ with serum total protein as the dependent variable, calf breed and calf sex as fixed effects, and farm of origin as a random effect. The assumption of equal variance was assessed by examining plots of residuals vs predicted values.

In our study, 3,080 calves (85.4%) were male, 417 calves (11.6%) were female and 111 calves (3.1%) did not have their sex recorded. Calves were identified as Holstein-Friesian (n = 1664, 46.1%), Jersey (n = 750, 20.8%) or other/crossbreed (n = 1153, 32.0%); 41 calves (1.1%) did not have their breed recorded. Ear tag scans at both loading for transport and at slaughter were available for 3124 (87%) calves. Of these, 2,916 (93%) were slaughtered within 24 h of leaving the farm, and 208 (7%) were slaughtered within 48 hours. Eight additional calves were excluded from this analysis due to times exceeding 72 h, which we considered were likely to be erroneous. Only calves originating from Victoria were included in the datasets.

Thirty-six percentage of the calves sampled had serum total protein concentrations of 52 g/L or less (Table 1, Figure 1), which is indicative of FPIT (immunoglobulin G ≤ 10 g/L).¹⁰ Using more recent consensus classifications for passive immunity transfer (PIT),¹ 31% of calves had poor PIT (<51 g/L), while 19% had fair PIT (51–57 g/L, Table 1), meaning that 50% of the calves sampled had sub-optimal PIT. Results of the linear mixed model show that Holstein-Friesian calves had total protein concentrations that were an estimated 5.3 g/L lower than

Jerseys, and 5.1 g/L lower than other/crossbreeds (Table 2). We did not detect an effect of sex on serum total protein concentration.

Approximately 10% of the random variability in serum total protein could be accounted for by the farm of origin in the model. Figure 2 shows a high degree of variability between farms in the proportion of calves with FPIT, for a subset of farms with 10 or more calves in the dataset. Only one farm out of the 82 in this subset avoided FPIT (serum total protein ≤52 g/L) for all calves included in our dataset. These results are consistent with previous research in Australian heifer calves, which reported a high variability of herd FPIT prevalence (0% to more than 75%).^{3, 4}

Management factors that could affect the prevalence of FPIT on farms include colostrum quality, colostrum volume ingested, the timing of colostrum feeding, and whether calves are given colostrum by the farmer or rely on suckling. These factors and others may account for the variability in FPIT prevalence between farms.

PIT can be reliably measured using serum total protein in calves up to 9 days old.¹¹ The vast majority of calves in this study were likely to be younger than 9 days old at slaughter, based on Dairy Australia survey data indicating most Victorian calves are 7 days old or less at transport, combined with our ear tag time stamp data indicating most calves were slaughtered within 24 hours of leaving the farm. However, it is possible that some calves were older than 9 days old. If a proportion of calves were older than 9 days, this could result in under-diagnosis of FPIT, as endogenous protein production could affect total protein concentrations.¹¹

Our study showed that Jersey and other/crossbreed calves had higher serum total protein concentrations than Holstein-Friesians, which is consistent with previous research by Vogels et al.³ Holstein-Friesian cows have been reported to show trends towards lower colostrum immunoglobulin concentration compared with Jerseys,¹² and Jersey calves have been shown to absorb immunoglobulins more efficiently than Holstein-Friesians.¹³ These may be some of the reasons why Jersey calves in our study had higher total protein concentrations than Holstein-Friesians.

One limitation of our study is that calves that died or were euthanased prior to slaughter were not sampled. Additionally, some of the calves in this cohort may have been dehydrated, for example, due to fasting or disease, and dehydration can lead to increases in total protein concentration.¹⁴ The presence of any calves older than 9 days of age could also result in under-diagnosis of FPIT.¹¹ For these reasons, our estimate of FPIT prevalence in bobby calves could be an underestimate of the true prevalence. Conversely, it is possible that collection of blood at exsanguination may have led to decreased serum total protein results via tissue fluid contamination, though the degree of contamination is likely to have been minor and thus the effect negligible.¹⁵

In conclusion, we found evidence of FPIT (serum total protein <52 g/L) in 36% of Victorian bobby calves sampled at three abattoirs, which, contrary to expectations, is comparable to the FPIT prevalence reported in previous research focussed on Australian heifer calves.^{3, 4} Fifty percent of bobby calves had poor or fair PIT (serum total protein <58 g/L).¹ The high prevalence of sub-optimal PIT in bobby calves could have implications for calf welfare prior to slaughter, as well as for the viability and profitability of dairy-beef production in the future.

Table 1. Descriptive statistics for serum total protein measurements for 3,608 Victorian bobby calves from 956 farms at three abattoirs

| | | Recommended herd level standards |
|--|--------------|----------------------------------|
| Mean TP | 58 g/L | |
| Median TP | 57 g/L | |
| Range TP | 9–109 g/L | |
| SD TP | 13 g/L | |
| No. calves with FPIT using cut point of TP ≤52 g/L (%) | 1312 (36.4%) | |
| No. calves with excellent PIT (≥62 g/L) (%) | 1421 (39.4%) | >40% |
| No. calves with good PIT (58–61 g/L) (%) | 376 (10.4%) | ~30% |
| No. calves with fair PIT (51–57 g/L) (%) | 688 (19.1%) | ~20% |
| No. calves with poor PIT (<51 g/L) (%) | 1123 (31.1%) | <10% |

Binary cut point for FPIT from Cuttance et al.,¹⁰ passive transfer categories and herd level recommendations from Lombard et al.¹ FPIT, failure of passive immunity transfer; PIT, passive immunity transfer; TP, total protein.

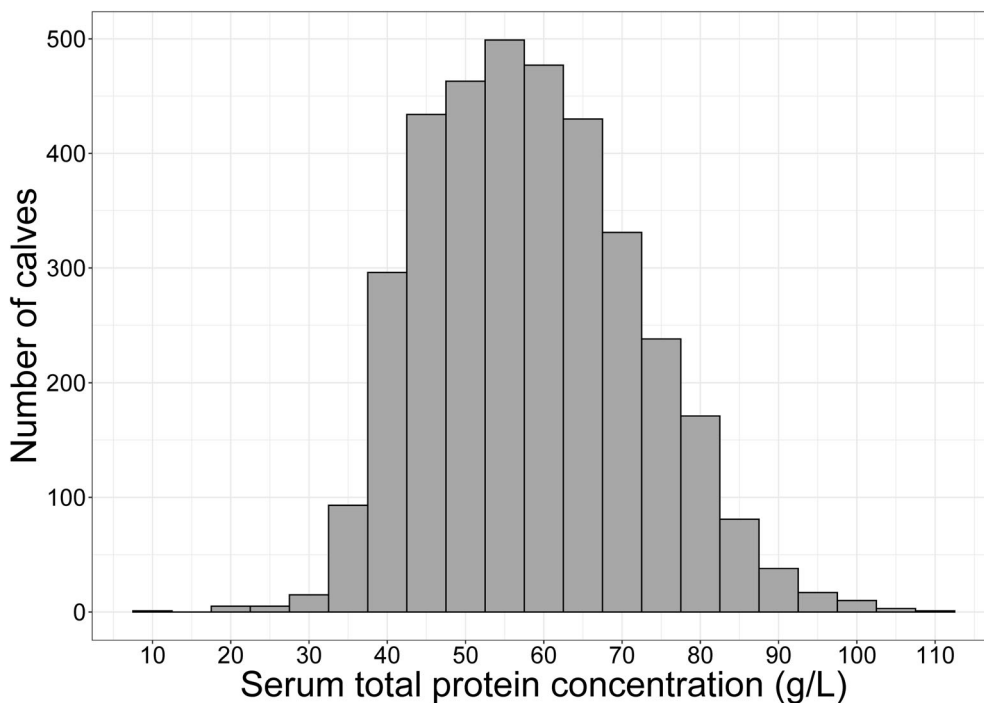


Figure 1. Serum total protein concentration of 3,608 Victorian bobby calves from samples collected at three abattoirs.

Table 2. Linear mixed model results for serum total protein measurements from 1818 Victorian bobby calves from 174 farms, from samples taken at three abattoirs

| Explanatory variable | Estimated mean (g/L) | 95% CI for difference vs baseline | P-value vs baseline |
|--------------------------------------|----------------------|-----------------------------------|---------------------|
| Breed – Holstein-Friesian (baseline) | 56.0 | | |
| Breed – Jersey | 61.3 | (3.5, 7.1) | <0.001 |
| Breed – Other/crossbreed | 61.1 | (3.7, 6.6) | <0.001 |
| Sex – Male (baseline) | 59.4 | | |
| Sex – female | 59.5 | (–2.0, 2.1) | 0.983 |

CI, confidence interval.

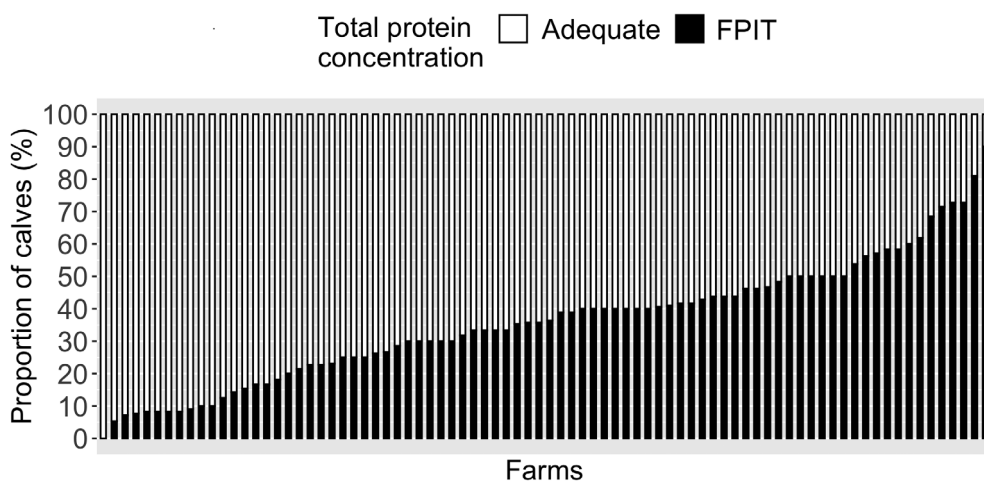


Figure 2. Percentage of bobby calves with failure of passive immunity transfer (FPIT, total protein ≤ 52 g/L⁹ (filled) compared with adequate passive transfer (total protein > 52 g/L, unfilled), for farms with 10 or more calves in the dataset (82 farms). Each column represents one farm.

Acknowledgments

The authors gratefully thank the staff at all participating abattoirs for allowing the use of their animals and access to facilities. We also warmly acknowledge our colleagues who helped with sample collection and processing: Laura Field, Pablo Alvarez, Tracie Storey and Andrew Carlyon, from the Animal Welfare Science Centre; and Fiona Armour, Daniel Pilbeam, Debra Kirkham and Amanda Hall from U-Vet Clinical Pathology Laboratory. Many thanks also to Louise Sundermann from Dairy Australia for providing data on the age of bobby calves at transport, and to staff at the Department of Jobs, Precincts and Regions who provided data on ear tag time stamps. Open access publishing facilitated by The University of Melbourne, as part of the Wiley - The University of Melbourne agreement via the Council of Australian University Librarians.

Conflict of interest and sources of funding

This work was supported by Meat and Livestock Australia, Lactalis Australia, an Australian Government Research Training Program Scholarship, and a Meat and Livestock Australia Postgraduate Scholarship/Study Award. The authors declare no conflicts of interest.

References

- Lombard J, Urie N, Garry F et al. Consensus recommendations on calf- and herd-level passive immunity in dairy calves in the United States. *J Dairy Sci* 2020;103(8):7611–7624.
- Cuttance EL, Mason WA, Laven RA et al. The relationship between failure of passive transfer and mortality, farmer-recorded animal health events and body weights of calves from birth until 12 months of age on pasture-based, seasonal calving dairy farms in New Zealand. *Vet J* 2018;236:4–11.
- Vogels Z, Chuck GM, Morton JM. Failure of transfer of passive immunity and agammaglobulinaemia in calves in south-west Victorian dairy herds: prevalence and risk factors. *Aust Vet J* 2013;91:150–158.
- Abuelo A, Havrlant P, Wood N et al. An investigation of dairy calf management practices, colostrum quality, failure of transfer of passive immunity, and occurrence of enteropathogens among Australian dairy farms. *J Dairy Sci* 2019;102:8352–8366.
- Wilson DJ, Stojkov J, Renaud DL et al. Risk factors for poor health outcomes for male dairy calves undergoing transportation in western Canada. *Can Vet J* 2020;61:1265–1272.
- Roadknight N, Mansell P, Jongman E et al. Blood parameters of young calves at abattoirs are related to distance transported and farm of origin. *J Dairy Sci* 2021;104(8):9164–9172.
- Bates D, Mächler M, Bolker B et al. Fitting linear mixed-effects models using lme4. *J Stat Softw* 2015;67(1):1–48.
- Kuznetsova A, Brockhoff PB, Christensen RHB. lmerTest package: Tests in linear mixed effects models. *J Stat Softw* 2017;82(13):1–26.
- R Core Team. R: A language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. 2020.
- Cuttance EL, Mason WA, Denholm KS et al. Comparison of diagnostic tests for determining the prevalence of failure of passive transfer in New Zealand dairy calves. *N Z Vet J* 2017;65:6–13.
- Wilm J, Costa JHC, Neave HW et al. Serum total protein and immunoglobulin G concentrations in neonatal dairy calves over the first 10 days of age. *J Dairy Sci* 2018;101:6430–6436.
- Phipps AJ, Beggs DS, Murray AJ et al. Factors associated with colostrum immunoglobulin G concentration in northern-Victorian dairy cows. *Aust Vet J* 2017;95:237–243.
- Jones CM, James RE, Quigley JD 3rd et al. Influence of pooled colostrum or colostrum replacement on IgG and evaluation of animal plasma in milk replacer. *J Dairy Sci* 2004;87:1806–1814.
- George JW, Zabolotzky SM. Water, electrolytes, and acid base. In: Latimer KS, editor. *Duncan & Prasse's veterinary laboratory medicine: Clinical pathology*. 5th edn. Wiley-Blackwell, West Sussex, England, 2011; 145–171.
- Roadknight N, Courtman N, Mansell P et al. Blood collection from dairy calves at exsanguination post-slaughter yields similar biochemical and packed cell volume measurements compared with in vivo collection during lairage. *Res Vet Sci* 2020;130:41–47.

(Accepted for publication 14 March 2022)