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Tests for failure of passive transfer of immunity and associations with health and performance in calves
Effect of floor type and space allowance on the performance and welfare of finishing beef cattle

Key external stakeholders:

Beef and dairy farmers; Teagasc KT, Department of Agriculture, Food and the Marine (DAFM), veterinary surgeons, Animal Health Ireland (AHI), Bord Bia..

Practical implications for stakeholders:

- Colostrum-derived passive immunity is central to the health, performance and welfare of neonatal calves. Calves with lower passive immunity were at greater risk of a negative health event or poor growth
- Calves with inadequate passive immunity are at greater risk of calfhood disease.
- Passive immunity test results can be categorised for failure of passive transfer (FPT) using test-specific cut-off values.
- Farmers should consider implementing a testing programme to monitor calf passive immune status.

Main results:

- Suckler beef calves had lower passive immunity compared to dairy calves. 20% of suckler beef and 30% of dairy calves were treated for at least one disease event by 6 mo. of age.
- Test cut-offs for failure of passive transfer risk, based on health and growth outcomes, varied
- Suckler beef calves had greater odds of bovine respiratory disease (BRD; odds ratio (OR), 95% confidence interval (CI): 2.8, 1.2 – 6.5, P=0.01), navel infection (5.1, 1.9 – 13.2, P<0.001), and joint infection/lameness (3.2, 1.3 – 7.8, P = 0.01) during the first 6 mo. of life than dairy calves. In addition, from birth to 6 mo. of age, suckler beef calves had greater rates of navel infection (incidence rate ratio (IRR), 95% CI: 3.3, 1.3 – 8.4, P=0.01), but decreased rates of diarrhoea (0.9, 0.2 – 0.9, P=0.03) compared to dairy calves.
- Optimal test cut-offs for classification of morbidity and mortality outcomes in suckler **beef calves** ranged from 8 to 9 mg/ml ELISA, 56 to 61 g/l TP – CA, 26 to 40 g/l globulin, 12 to 18 ZST units, 8.4% TS – BRIX, and 5.3 to 6.3 g/dl TP – DR.
- Optimal test cut-offs for classification of morbidity and growth outcomes in **dairy calves** ranged from 10 to 12 mg/ml ELISA, 57 to 60 g/l TP – CA, 29 to 34 g/l globulin, 19 ZST units, 7.8 to 8.4% TS – BRIX, and 5.7 to 5.9 g/dl TP – DR.

Opportunity / Benefit:

Neonatal calves are dependent on passive immunity, acquired through the ingestion and absorption of colostral Ig, for protection against infectious disease challenges in early life. In the present study, passive immunity test results for suckler beef calves were lower than that of dairy calves. This response was unexpected, yet consistent across each passive immunity test. Passive immunity and associations with calf health and performance parameters were evaluated in the present study. Overall, these results provide further evidence that calves with lower passive immunity test results are at greater risk of experiencing a negative health event or poor growth performance. There are still opportunities for improvement in colostrum management on Irish suckler and dairy farms.

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Collaborating Institutions: UCD, AFBI

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External collaborators: Dr. Ingrid Lorenz (UCD); Dr. Steven Morrison, (AFBI).

1. Project background:

The first and most important feed provided to a newborn calf is maternal colostrum, which supplies immunoglobulins and other important nutrients. Immunoglobulins protect the calf against foreign agents, such as bacteria and viruses. As the calf is born without an active immune system, colostrum-derived passive immunity is essential in maintaining neonatal calf health, and thus, reducing morbidity and mortality. Failure of passive transfer (FPT) of immunity occurs when the calf does not absorb sufficient colostral immunoglobulins immediately after birth. In Ireland, the most recent large-scale study on FPT in calves was conducted more than 3 decades ago by Fallon and Harte (1987*). With this earlier work, a sample of 4,130 purchased Friesian male calves were assessed for FPT using the zinc sulphate turbidity (ZST) test, and 52 and 34 % of calves had less than 20 and 15 ZST units, respectively. More recently, O'Shaughnessy et al. (2015) documented that 22% of calves on 16 Irish suckler beef farms had FPT, which was defined as less than 20 ZST units. In addition, the All-Island Animal Disease Surveillance Programme has reported that between 38 and 66.5% of calf serum samples submitted annually to the regional veterinary laboratories in the Republic of Ireland and Northern Ireland have less than 20 ZST units (Department of Agriculture, Food and the Marine (DAFM) and Agri-Food and Biosciences Institute, 2010-2016). These passive surveillance estimates on FPT may not, however, truly reflect the overall national herd status because they are drawn from voluntary submissions, often from clinically ill calves or animals from herds with recurring calf health problems. Furthermore, there is no recent published information on the passive immune status of calves from modern genotypes in commercial Irish suckler beef and dairy farms. Hence, there is a need for updated information on the FPT status of Irish calves.

*Fallon, R.J., Harte, F.J., 1987. A survey of factors affecting calf blood serum immunoglobulin level. Ir. J. Agric. Res 26, 1–7

2. Questions addressed by the project:

The primary aim of this study was to evaluate the diagnostic performance of passive immunity tests for FPT classification by identifying test cut-off values associated with increased risk of morbidity, mortality, or poor growth in calves.

A secondary aim was to describe the epidemiology of morbidity and mortality in Irish suckler beef and dairy calves.

3. The experimental studies:

3.1 Tests for failure of passive transfer of immunity and morbidity and mortality recordings

A total of 1,392 calves from 111 suckler beef farms, and 2,090 calves from 84 dairy farms across Ireland, were enrolled in the study. Calves were born between July 2014 and June 2016, and monitored until 6 months of age. Each farm visit was scheduled to coincide with a time when calves would be available for blood sample collection and FPT assessment. Calves between 1 and 21 days of age were eligible for blood sampling. A maximum of 12 calves were blood sampled at each farm visit. The median age at blood sample collection for suckler beef and dairy calves was 10 and 9 days of age, respectively. Blood samples were collected by jugular venepuncture and serum was harvested. Serum was analysed for total IgG (by ELISA), globulin and total protein (TP) by clinical analyser (TP-CA), zinc sulphate turbidity (ZST), TS – Brix %, and TP by digital refractometer (TP-DR). Farmers recorded information on disease events, health treatments, and calf mortality. Morbidity data were available for 1,192 suckler (n=84 farms) and 1,733 dairy calves (n=55 farms). Mortality data were available for all calves. Standardised 205-day body weight was determined for 450 suckler (n = 9 farms) and 480 dairy (n = 8 farms) calves.

4. Main results:

4.1 Passive immunity test results

Suckler beef calves had lower mean values compared to dairy calves, across all of the tests for passive immunity (Table 1).

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Table 1. Passive immunity test results for suckler beef (n = 1,392) and dairy calves (n = 2,090)

	Suckler calves		Dairy calves		
	Mean	**Range**	**Mean**	**Range**	**Significance**
ELISA IgG (mg/ml)	12.0	(1.5 - 47.5)	14.0	(1.5 - 55.5)	*
Total protein – clinical analyser (g/l)	60.3	(36.7 - 87.7)	62.7	(39.8 - 93)	*
Globulin (g/l)	33.1	(12.4 - 67.1)	35.2	(13.9 - 68.5)	*
ZST (Units)	15.9	(0.3 - 52)	17.5	(0.5 - 51.4)	*
Total solids (Brix %)	8.8	(6 - 13.6)	9	(6 - 13.2)	*
Total protein – digital refractometer (g/dl)	5.9	(1.5 - 8.7)	6.2	(3.2 - 9.6)	*

*Significant difference; suckler beef calves compared with artificially-reared dairy calves

FPT test cut-offs for suckler beef calves

Optimal IgG ELISA cut-offs for classification of morbidity and mortality in suckler beef calves were 8 and 9 mg/ml, respectively (Table 2). Suckler beef calves with IgG ELISA values ≤ 8 mg/ml had greater odds of being treated for at least one disease event by 3 months of age or BRD in the first month of life compared to those calves with ELISA values > 8 mg/ml. The odds of suckler beef calves with ELISA values ≤ 9 mg/ml dying by 6 months of age were almost threefold that of those with ELISA values > 9 mg/ml. Other test cut-offs that optimally classified suckler beef calves for health outcomes ranged from 56 to 61 g/l TP-CA, 26 to 40 g/l globulin, 12 to 18 ZST units, 8.4 % Brix, and 5.3 to 6.3 g/dl TP-DR.

FPT test cut-offs for artificially-reared dairy calves

Cut-offs that optimised classification of dairy calves for subsequent health and performance ranged from 10 to 13 mg/ml for the ELISA direct test (Table 2). Dairy calves with ELISA values ≤ 10 mg/ml had greater odds of having reduced body weight post-weaning than those with ELISA values > 10 mg/ml. Dairy calves with ELISA values ≤12 mg/ml had greater odds of BRD treatment in the first 6 months of life than those with ELISA >12 mg/ml. Conversely, dairy calves with ELISA values ≤ 13 mg/ml had 40% lower odds of diarrhoea from birth to 6 months of age than dairy calves with ELISA values >13 mg/ml. Other test cut-offs that optimally classified dairy calves for health and growth outcomes ranged from 57 to 66 g/l TP-CA, 29 to 36 g/l globulin, 19 to 23 ZST units, 7.8 to 9.4 % Brix, and 5.7 to 6.8 g/dl TP-DR.

Table 2. Test cut-offs that optimally classified suckler beef calves and dairy calves for health outcomes

FPT Variable measured	**Test**	**Suckler beef calves**	**Dairy calves**
ELISA IgG (mg/ml)	Lab-based	8 - 9	10 - 12
Total protein – clinical analyser (g/l)	Lab-based	56 - 61	57 - 60
Globulin (g/l)	Lab-based	26 - 40	29 - 34
ZST (Units)	Lab-based	12 - 18	19
Total solids (Brix %)	On-farm	8.4	7.8 - 8.4
Total protein - digital refractometer (g/dl)	On-farm	5.3 - 6.3	5.7 - 5.9

The ZST test is the most frequently used test in Ireland, with serum samples submitted to the regional veterinary laboratories being analysed using this test. In the Teagasc study, optimal ZST units for classification of health outcomes in suckler beef and dairy calves ranged from 12 to 18 units and 19 units, respectively. Thus, if FPT was defined based on the optimal ZST cut-offs, upwards of 64% of suckler beef and 65% of dairy calves would have been classified as having FPT. The most commonly applied cut-off for diagnosing FPT in calves is 20 ZST units. Hogan et al. (2015) recently documented that a ZST cut-off of 20 units is likely too high. In a comparison against IgG ≥ 10 mg/ml using single radial immunodiffusion (sRID), they proposed a cut-off of 11 ZST units, which resulted in improved specificity for the test.

Results of the present study also suggest that a lower ZST cut-off is warranted. In the present study, 74 and 46% of suckler beef, and 68 and 54% of dairy calves had less than 20 and 15 ZST units, respectively. Thus, it is evident that there are still opportunities for improvement in colostrum management on Irish farms. Measuring serum TP using a hand-held refractometer offers a convenient, simple, rapid and

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inexpensive on-farm tool by which producers and veterinarians can measure serum immunoglobulin concentrations, thereby allowing assessment of colostrums-feeding protocols. Brix –TS values performed just as well as TP - DR values versus the gold standard ELISA (ELISA values vs. Brix – TS: *r* = 0.77; Brix – TS vs. TP – DR: *r* = 0.76) for evaluating passive transfer.

4.2 Epidemiology of morbidity and mortality in Irish suckler beef and dairy calves

Overall, 20.4% of suckler beef calves and 14.8% of dairy calves were treated with antibiotics for disease by 6 months of age. The leading cause of morbidity from birth to 6 mo. of age in the present study was diarrhoea, accounting for 44 and 77% of the disease events in suckler beef and dairy calves, respectively. The second and third most frequent causes of morbidity in calves during the first 6 mo. of life were BRD and navel infection, respectively. Suckler beef calves had greater odds of BRD, navel infection, and joint infection/lameness, as well as increased rate of navel infections during the first 6 months of life compared to dairy calves. Conversely, the incidence rate of diarrhoea from birth to 6 months of age was greater in dairy calves than suckler beef calves. Incidence rates of crude morbidity for suckler beef and dairy calves from birth to 6 mo. of age were 4.1 and 8.7 disease events per 100 calf-mo. at risk, respectively.
In total, 2.7% of suckler beef and 3.3% of dairy calves died in the first 6 mo. of life. Incidence rates of mortality from birth to 6 mo. of age were 0.5 and 0.6 deaths per 100 calf-mo. at risk for suckler beef and dairy calves, respectively. The odds of mortality between 1 and 3 mo. of age tended to be 1.8-times greater in suckler beef vs. dairy calves. Suckler beef and dairy calves did not differ for cumulative incidence of mortality in any of the other age categories. Median age at death for suckler beef and dairy calves was 51 and 27 days, respectively. More than half of the dairy calf deaths occurred within the first 1 mo. of life; whereas, the majority of suckler beef calves died between 1 and 3 mo. of age. All suckler beef calf deaths occurred on the calves' home farm; whereas 23% (16/69) of dairy calf deaths occurred after they had left the home farm. Results of this study provide insight into the relationships between passive immunity, morbidity and mortality of suckler beef and dairy calves under field conditions in Ireland.

5. Opportunity/Benefit:

Neonatal calves are dependent on passive immunity, acquired through the ingestion and absorption of colostral Ig, for protection against infectious disease challenges in early life. In the present study, passive immunity test results for suckler beef calves were lower than that of dairy calves. This response was unexpected, yet consistent across each passive immunity test. Passive immunity and associations with calf health and performance parameters were evaluated in the present study. Overall, these results provide further evidence that calves with lower passive immunity test results are at greater risk of experiencing a negative health event or poor growth performance. There are still opportunities for improvement in colostrum management on Irish suckler and dairy farms.

6. Dissemination:

In-service training, Animal Health Ireland (CalfCare events), Teagasc Open Days, Teagasc Fact sheets

Scientific publications:

1. Dunn, A., Duffy, C., Gordon, A., Morrison, S.J., Argűello, A., Welsh, M., **Earley**, B. (2018) 'Comparison of single radial immunodiffusion and ELISA for the quantification of immunoglobulin G in bovine colostrum, milk and calf sera' *Journal of Applied Animal Research*, 46:1, 758-765.
2. **Earley**, B., Tiernan, K., Duffy, C., Dunn, A., Waters, S.M., Morrison, S., McGee, M. (2018) 'Effect of suckler cow vaccination against glycoprotein E (gE)-negative bovine herpesvirus type 1 (BoHV-1) on passive immunity and physiological response to subsequent bovine respiratory disease vaccination of their progeny' *Research in Veterinary Science*, 118, Pages 43-51.
3. Dunn, A., Duffy, C., Gordon, A., Morrison, S.J., Argűello, A., Welsh, M., **Earley**, B. (2018) 'Effect of passive transfer status on response to a glycoprotein E (gE)-negative bovine herpesvirus type 1 (BHV-1) and bovine respiratory syncytial virus (BRSV) vaccine and weaning stress in pre-weaned dairy calves' *Journal of Applied Animal Research*, 46 (1) 907-914.

Popular publications:

1. BEEF2018 Grange "€nhancing Technologies" Animal health & breeding village, 26th June 2018.

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