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Welcome

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Contents

Oral Presentations

Posters

Worms – Resistance and Moxidectin on Scottish Sheep Farms

Jennifer McIntyre

Application: Moxidectin, a macrocyclic lactone (ML), is a highly potent endectocide. How Scottish shepherds currently use moxidectin, and its efficacy in Scotland, is unknown. This study aims to answer these questions and perform knowledge exchange to encourage sustainable use.

Introduction: In 2012 a UK wide survey found 56% of farmers used MLs to manage parasitic nematodes, but none reported ML resistance (Burgess et al., 2012). Yet testing for anthelmintic resistance identified 50% of farms with avermectin resistance and 19 to 62% with moxidectin resistance (Hybu Cig Cymru, 2015; McMahon et al., 2013). Many farmers use moxidectin at lambing time, although benefits of this for lamb production and faecal egg count are unclear (Learmount et al., 2018; Kerr et al., 2020), and the most recent SCOPs advice is to limit year on year use of moxidectin for this purpose. Moxidectin products have persistent action, and can reduce pasture larvae (Kerr et al., 2020), but may intensify resistance development, especially if parasites in refugia are few. This study investigates current prevalence of anthelmintic resistance in Scotland, how Scottish shepherds use moxidectin, and tests for moxidectin resistance.

Material and methods: An online questionnaire assessing anthelmintic use, resistance and worm management has been generated in collaboration with researchers at Queen's University Belfast and will be widely disseminated. A shorter version will be distributed in paper form. Thirty Scottish shepherds will collect faecal samples from 15 ewes treated with moxidectin at lambing and complete a questionnaire focused on their moxidectin use and anthelmintic resistance. Samples will be collected 14-17 days post-treatment, and again within the persistency period (5-13 weeks) to assess both 'head' and 'tail' resistance. Individual faecal egg counts will be obtained, using the cuvette method (sensitive to 1 egg per gram). Faeces will be cultured for 10 days at 25 °C, and L3 larvae baermannised. PCR of the ITS2 region will be performed to identify resistant species.

Results: This study is ongoing, but results-to-date will be presented. The author has previously identified ivermectin and benzimidazole dual-resistant Teladorsagia circumcincta, on a farm where moxidectin was used at lambing time, followed by repeated benzimidazole use. Moxidectin was considered effective by faecal egg count reduction test, but some T. circumcincta survived treatment.

Conclusion: Moxidectin may increase development of anthelmintic resistance, and sustainable use is essential. Key to the project is dissemination of findings to farmers and the wider sheep industry, alongside promotion of updated SCOPS guidelines on appropriate moxidectin use.

Acknowledgements: The authors acknowledge funding from KTN, BSAS and the BBSRC (The BUG Consortium: BB/M003949).

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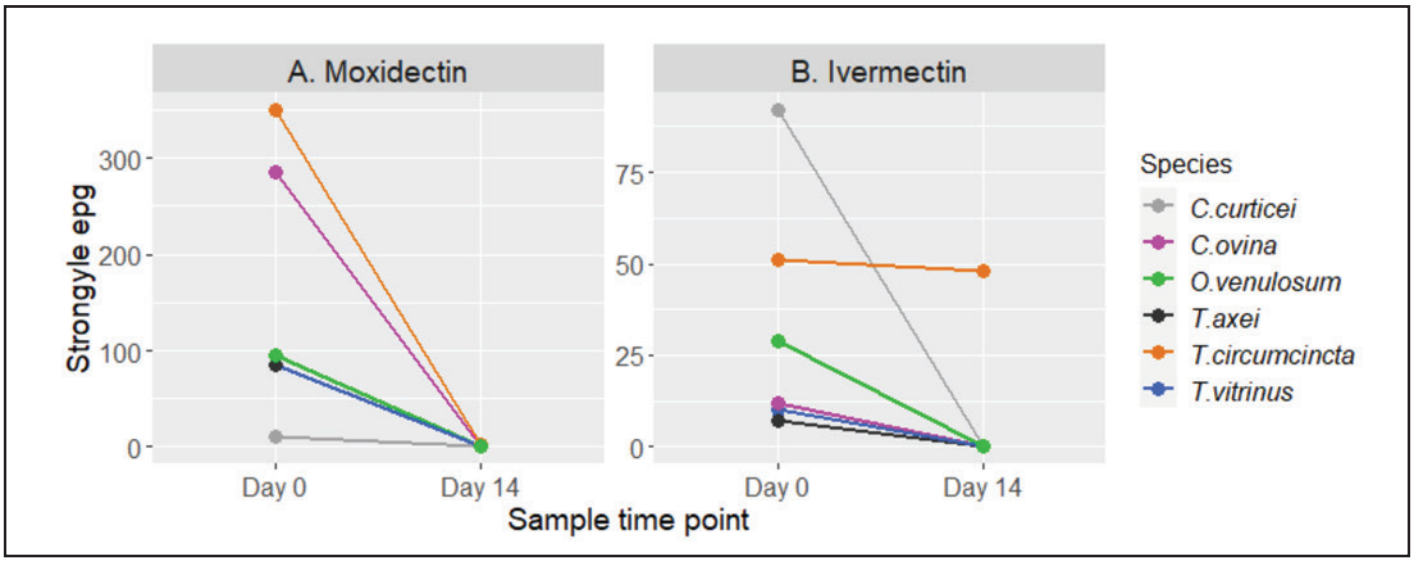
Figure 1: Change in faecal egg count by species proportion. (A) Moxidectin (B) Ivermectin



The efficacy of non-steroidal anti-inflammatory drugs for the treatment and prevention of lameness; a 3-year randomized controlled trial

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Application: Lameness presents a significant challenge to the future viability of the dairy industry with the immediate welfare challenge to the dairy cow being of primary concern. Our research has identified a simple intervention which can substantially reduce the risk of an animal being scored as lame or being culled.

Introduction: Claw horn lesions are the most prominent cause of lameness in intensive dairy systems (Solano et al., 2016). The pathogenesis driving the occurrence of these lesions has been linked to localized inflammation within the foot of the dairy cow (Newsome et al., 2016) and further evidence suggests that systemic inflammation around calving may be important to determine the likelihood of health events in the next lactation (Bradford et al., 2015). However, the extent to which inflammatory changes at calving impact the risk of lameness is unknown. This randomized controlled trial was designed to test the effect of non-steroidal anti-inflammatory drugs administered at calving and at lameness treatment, on the risk of lameness and culling.

Materials & Methods: All heifers belonging to a single commercial dairy unit were randomized to one of four treatment groups (described briefly in table 1) stratified by expected calving date. These animals calved between 01/2018 and 06/2020 and were managed in line with the remaining herd. All animals in the study herd were continuously housed and milked three times daily. Study animals were treated for lameness (diagnosed by lameness scoring) on a fortnightly basis according to their respective group treatment regimens between January 2018 and October 2020. All lactating animals in the herd were lameness scored on a fortnightly basis by independent, trained lameness scorers who were blinded to treatment groups to attain an unbiased "outcome" lameness score. The final denominators of animals that successfully calved and were presented for scoring are presented in Table 1. Two mixed-effects logistic regression models were constructed to investigate the effects of treatment group on the risk of being scored as lame and severely lame. A conventional Cox proportional hazards model was constructed to assess the effects of treatment group on the risk of culling.

Results: Preliminary data analysis has identified that targeted intervention with non-steroidal anti-inflammatory drugs reduced the risk of an animal being identified as lame and decreased the risk of an animal being culled at any point in the study. In conclusion the results indicate that strategic use of NSAIDs can play a substantial role in the prevention of lameness in dairy cows. Full results will be presented at the conference.
Table 1 Summary of the four treatment regimens applied in a three year randomised controlled trial investigating the efficacy of non-steroidal anti-inflammatory drugs in the treatment of lameness.

Acknowledgements: This work was funded by the Agriculture and Horticulture Development Board (AHDB) Dairy Division (Kenilworth, UK), a levy board, not-for-profit organization working on behalf of British dairy farmers. We also acknowledge the owners at Gleadthorpe farm for allowing the use of their facilities, and the persistent effort the staff employed to support the implementation of this RCT.

Treatment Group	Treatment trim when identified as lame	Course of NSAID when identified as lame	Course of NSAID at calving
Group 1 n = 111	Y	N	N
Group 2 n = 117	Y	Y	N
Group 3 n = 100	Y	Y	Y
Group 4 n = 110	N	Y	N

Quantitative analysis of calf mortality in Great Britain

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Application: Mortality rates of calves in Great Britain (GB) can be calculated from national databases, and have great potential in monitoring trends and identifying potential risk factors.

Introduction: National bodies in GB have expressed concern over young stock health and welfare and identified calf survival as a priority; however, no national data have been available to quantify mortality rates. The aim of this study was to quantify the temporal incidence rate, distributional features, and factors affecting variation in mortality rates in calves in GB since 2011. The purpose was to provide information to national stakeholder groups to inform resource allocation both for knowledge exchange and future research.

Material and methods: Cattle birth and death registrations from the national British Cattle Movement Service were analysed to determine rates of both slaughter and on-farm mortality. The number of births and deaths registered between 2011 and 2018 within GB were 21.2 and 21.6 million, respectively.

Results: Of the 3.3 million on-farm deaths, 1.8 million occurred before 24 mo of age (54%) and 818,845 (25%) happened within the first 3 mo of age. The on-farm mortality rate was 3.87% by 3 mo of age, remained relatively stable over time, and was higher for male calves (4.32%) than female calves (3.45%). Dairy calves experience higher on farm mortality rates than nondairy (beef) calves in the first 3 mo of life, with 6.00 and 2.86% mortality rates, respectively (Figure 1). The 0- to 3-mo death rate at slaughterhouse for male dairy calves has increased from 17.40% in 2011 to 26.16% in 2018, and has remained low (<0.5%) for female dairy calves and beef calves of both sexes. Multivariate adaptive regression spline models were able to explain a large degree of the variation in mortality rates (coefficient of determination = 96%). Mean monthly environmental temperature and month of birth appeared to play an important role in neonatal on-farm mortality rates, with increased temperatures significantly reducing mortality rates. Taking the optimal month of birth and environmental temperature as indicators of the best possible environmental conditions, maintaining these conditions throughout the year would be expected to result in a reduction in annual 0- to 3-mo mortality of 37,571 deaths per year, with an estimated economic saving of around £11.6 million (USD $15.3 million) per annum based on an estimated cost of £310 per calf death (Kossaibati and Esslemont, 1997).

Conclusions: National cattle registers have great potential for monitoring trends in calf mortality and can provide valuable insights to the cattle industry. Environmental conditions play a significant role in calf mortality rates and further research is needed to explore how to optimize conditions to reduce calf mortality rates in GB.

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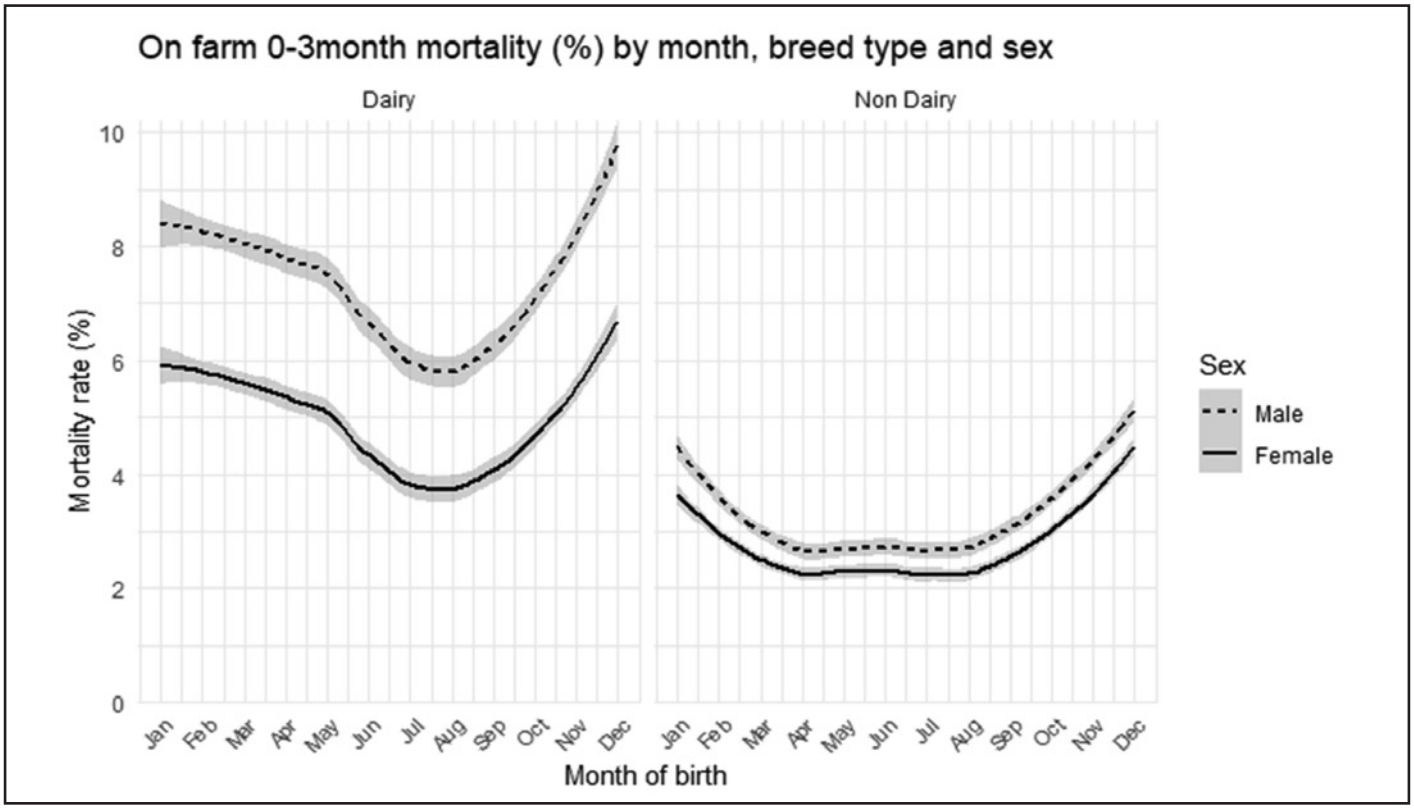

Effect of mobility on milk yield, dry matter intake, live weight and feed efficiency in dairy cows

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Application: Understanding the effects of suboptimal mobility on dry matter intake and milk yield provides dairy farmers greater opportunities to make clearer decisions with regard to animal welfare and feed utilisation.

Introduction: Lame cows typically spend more time lying, and less time feeding than sound cows (Chapinal et al., 2009). Increased mobility score (MS) lowered the number of meals consumed by dairy cows (Huxley, 2013). This study aimed to assess the effect of MS on feed intake, milk production and feed efficiency of high yielding dairy cows.

Materials and methods: For 55 Holstein-Friesian dairy cows, individual live weight, feed intake and milk yield were recorded daily for the first 120 days of lactation. Individual animal's milk composition and MS were assessed weekly. The MS was assessed by the same observer using a scale of 0 to 3 (0; Good; 1: Imperfect; 2: Impaired; 3: Severely impaired) according to AHDB (Ahdb.org.uk). Data was normally distributed and analysed using REML (Genstat 20) with MS as a fixed effect and cow as a random effect in the model.

Results: A greater MS was associated with greater energy-corrected milk yield and parity, and there was a tendency for such cows to have a greater daily feed intake, while mean milk composition, live weight and feed efficiency (Table 1) was not affected by MS. Most cows were observed to have imperfect (1), followed by good (0) MS, while few had impaired (2) and none had a severely impaired (3) MS during the first 120 d pp. Conclusion: Younger cows, that had completed fewer parties were observed to have good MS more frequently than older cows of greater parity. These cows were more frequently observed to have imperfect and impaired MS and tended to have greater daily DMI. Cows observed to have impaired mobility had the greatest EC milk yield, but MS had no effect on feed efficiency. However, preventing the development of lameness in older cows remains essential in lowering its impact on animal welfare and treatment costs associated imperfect and impaired mobility.

Acknowledgements: C.G. was funded by a University of Nottingham scholarship under the AHDB Dairy - Nottingham Partnership on Health, Welfare and Nutrition.

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Chapinal N, de Passillé AM, Weary DM, von Keyserlingk MAG, Rushen J (2009). Journal of Dairy Science 92:4365-4374.
Huxley JN (2013). Livestock Science 156:64–70

Tables

	Mobility score				
	0	1	2	SED	P value
Observations, No	170	295	28	-	-
Milk yield, kg/d	47.8	47.8	49.5	0.84	0.202
EC milk yield, kg/d [2]	48.7 a	48.2 a	51.1 b	0.94	0.027
Milk fat, g/kg	40.0	39.1	41.5	1.192	0.129
Milk protein, g/kg	32.3	32.3	31.7	0.42	0.446
Dry matter intake, kg	23.6	24.3	24.6	0.53	0.074
Live weight, kg	738	742	744	3.9	0.168
Parity, No.	1.67[a]	2.33[b]	2.28[b]	0.1226	<0.001
Feed efficiency[3]	2.08	2.03	2.10	0.065	0.333

a, b - Means that do not share a letter are significantly different at P<0.05
2 – EC: Energy corrected milk yield, kg = 0.327 x milk yield kg + 12.95 x fat kg + 7.21 x protein kg
3 – Feed efficiency = ECM / dry matter intake

Undergraduate Thesis of the Year Winner

Phoebe Rose Abrahams

Free-roaming dog population management: The operative and postoperative health and welfare implications associated with dogs undergoing vasectomy versus orchiectomy in catch neuter return intervention programmes

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Abstract

Domestic dogs are present globally, and approximately 75% of the population is defined as "free-roaming". Free-roaming dog population management intervention is required to reduce the risks they present to humans, wild-animals and their own populations. Intervention methods include catch neuter return (CNR), culling and sheltering. Presently, in CNR programs, welfare assessments are often absent, and alternative neutering methods are not considered as a way to improve health and welfare. This study aims to determine the factors affecting the health and welfare and speed of recovery of male dogs undergoing the primary neutering technique; orchiectomy, and vasectomy, which is rarely used in practice. Operative and post-operative health and welfare data were collected from 152 male and female dogs undergoing gonadectomy and vasectomy procedures. A key finding of this study was that the duration of neutering surgery significantly increased throughout the day (Wald=5.678, df=1, p=0.017). Additionally, the duration of vasectomy surgery decreased over the 10-day intervention period (Wald=4.014, df=1, p=0.045). This result is due to the first-time vasectomy surgeons improving their skills in surgical technique over the intervention period. The underlying true cause of the effect of surgery start time is thought to be fatigue in the surgeons carrying out high-volume neutering surgery. The factors shown to influence the change in postoperative health and welfare should be interpreted with caution due to ramifications with the qualitative post-operative assessment protocol. This study is the first of its kind which has highlighted some critical areas.

Increased living space for housed dairy cows improved milk volume production in randomised control trial

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Application: Living space is a basic requirement for all farmed animals yet its fundamental impact on health and wellbeing remains unclear. This novel piece of research relates to the ethics of farming as well as the understanding of animal biology and has huge significance given the current high profile of intensive farming methods.

Introduction: The environment in which livestock are farmed will have fundamental impacts on health and wellbeing. Intensification of farming has become more commonplace but remains an emotive subject (Jackson et al., 2020). Most dairy cows globally are housed for 4-6 months of the year (March et al., 2014), yet virtually no evidence exists on the long-term effects of specific housing conditions. Even the most fundamental requirement, living space, has not been thoroughly evaluated (Thompson, 2020).
This study aimed to quantify the effect on production, reproduction and behaviour, of an increase in the living space allowance for adult dairy cows.

Material and Methods: This long-term randomised controlled trial was undertaken continuously over a 12-month period, in a unique, purpose-built facility, which allowed precise measurement and configuration of the housed area. All elements of the trial were conducted under license.

Adult Holstein dairy cows (n = 150) were randomly allocated to a 'high' living space group (living space = 6.5m2, total = 14m2) or 'commercial average' living space group (living space = 3m2, total = 9m2) (Thompson, 2020); all other aspects of the housed infrastructure (e.g. feed-face length, lying areas, water area, lighting, temperature, environmental enrichment etc.) were identical between groups.

Production data were recorded from Lely Astronaut A4 milking robots (daily cow yield and rumination time) and analysed using mixed effects models. Reproductive performance was evaluated using survival models of time (days) to conception. Cows were fitted with location sensors providing position and acceleration data for each cow using a novel wireless sensor system (Omnisense). Direct comparisons of time budgets for key behavioural activities (e.g. lying times) were made between groups.

Results: Compared to cows in commercial average space, cows with increased space, produced more milk per 305 day lactation (first parity cows; ~12200L vs ~11600L, $p<0.01$, parity >1 cows ~14700L vs ~14600L, $P<0.01$) but took longer to conceive (34d, $p<0.05$). Cows with less living space spent less time in lying (~1hr/d), instead spending more time in the passageways (~1.5hr/d: $P<0.05$). In terms of underlying physiology, cows with increased living space has increased rumination times (15 minutes/day, $P<0.05$).

Conclusion: This is the first long term study to demonstrate that increased living space results in meaningful benefits in terms of productivity and behaviour. It is likely that additional living space will be of benefit to adult dairy cows but further research is needed into the cost-effectiveness of providing extra space.

Acknowledgements: This work was funded by Agriculture and Horticulture Development Board (AHDB) Dairy.

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Effect of age at first calving on longevity and lifetime performance in Holstein-Friesian dairy heifers

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Application: Better understanding of the subsequent performance and longevity of heifers that do not meet rearing targets can improve efficiency and profit of dairy herds.

Introduction: A target age at first calving (AFC) of 24 months is recommended for dairy heifers. Rearing costs increase by £2.87 for every additional day over target AFC and it takes 1.5 lactations for a heifer to pay back her rearing costs (Boulton et al., 2017). The aim of this study was to examine lifetime performance of heifers in relation to achievement of target age at first calving.

Material and methods: Records were analysed from 551 Holstein-Friesian heifers born between 2007 and 2018 at the Nottingham University Centre for Dairy Science Innovation. Age at first calving was categorised as Early (< 700 d), Target (700 – 760 d), Late (760 – 852 d) and Very late (>852 d). Data examined from animals that left the herd were: live weight (LW) at first calving (LWFC), growth rate from birth to calving, LW/Mature weight (MW = mean LW of cows in lactation ⩾3), lifetime milk yield (LTMY) and days in milk (LTDIM), and days on farm (DoF). Longevity index was LTDIM/DoF. Data were analysed using Generalised Linear Models (GLM) in Genstat, with AFC as the fixed effect. Normal error distribution was used for LW, growth and milk yield data; Poisson error distribution with a log-linear link function was used for data comprising lactation number or days.

Results: Heifers that calved very late incurred greater rearing costs than those calving before or on target, had a greater first lactation yield but lower lifetime yield, and had more unproductive days (911 d) than productive days (733 d). Early calvers were the most likely to survive beyond 1.5 lactations.

Table 1: Performance of animals born between 2007 and 2018 according to age at first calving

	Age at first calving				SED	P value
	Early	Target	Late	Very late		
No of animals	105	189	190	67		
First calving						
Age at first calving, d	653[a]	733[b]	800[c]	911[d]	3.9	<0.001
Live weight at first calving, kg	517[a]	582[b]	606[c]	650[d]	7.9	<0.001
% MW at first calving	75.8[a]	82.5[b]	86.1[c]	91.6[d]	0.99	<0.001
Growth rate, kg/d	0.73[c]	0.73[c]	0.70[b]	0.67[a]	0.01	<0.001
Days over first calving target	-77[a]	5[b]	73[c]	183[d]	3.8	<0.001
Additional rearing costs, £1	-	14.35	209.51	525.21		
Performance						
First lactation milk yield, L	9660[a]	10458[ab]	11016[b]	11170[b]	543	0.033
Lifetime milk yield, L	36973[b]	30447[a]	30906[a]	27511[a]	2756	0.018
Average daily lifetime yield, L	18.2[b]	15.8[a]	15.8[a]	14.2[a]	0.86	<0.001
Lifetime days in milk	1067[b]	834[a]	839[a]	733[a]	86.2	0.004
Survivability						
% of cows exceeding 1.5 lactations	83.8[b]	69.3[a]	67.9[a]	70.1[a]	0.06	0.015
Lactation of removal	3.52[c]	2.84[b]	2.80[ab]	2.38[a]	0.21	<0.001
Days on farm	1838	1710	1741	1739	82.5	0.414
Longevity index	0.52[b]	0.43[a]	0.43[a]	0.38[a]	0.03	<0.001

[1]Calculated at £2.87/d

Conclusion: Heifers calving later than target AFC cost more to rear and produce less milk for fewer days than heifers calving earlier than target. This will affect efficiency and profitability of the herd. Results suggest that calving <700 d might be a better target for this herd.

Acknowledgements: L.R. was funded by a University of Nottingham postgraduate studentship.

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Redefining Key Performance Indicators for livestock production systems: what is the value of information?

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Application: Quantifying the combined information value of multiple KPIs can help farmers understand what information should be recorded on the farm to improve system-wide profitability.

Introduction: To facilitate improvement in production efficiency of the sheep industry (Lima et al., 2020), various metrics termed 'Key Performance Indicators' (KPIs) have been proposed (AHDB, 2019). However, the exact meaning of these metrics remains ambiguous, particularly regarding their relative importance and how much information should be measured to cost-effectively inform farm management decisions. Using high-resolution lamb data and matched ewe data collected at the North Wyke Farm Platform in Devon, UK, this study developed a novel framework to quantify the economic benefit of measuring KPIs under different intensities (number of metrics) and combinations.

Material and methods: Ten 'predictors', each measured on either a lamb or their mother before the relevant lamb's weaning, were shortlisted from the literature as KPIs to project the realised carcass value. The cut-off at weaning was imposed to ensure that information can be utilised to improve on-farm management during the lamb's lifetime. The information value of a group of predicters was defined as the difference in carcass value between top third (high) and bottom third (low) groups within the flock when animals are ordered using the average ranks across all predictors concerned. This difference represents the economic gain of an animal being 'upgraded' from low to high group under the assumption that such interventions are feasible. The process was repeated 1023 times to encompass all possible intensities (1–10) and combinations. The resultant information values were collated for each intensity level separately so that the relationship between the cost/effort of measurements and potential investment returns could be visualised. The dataset used comprised 1364 lambs and their mothers (389), reared across six grazing seasons between 2014 and 2019.

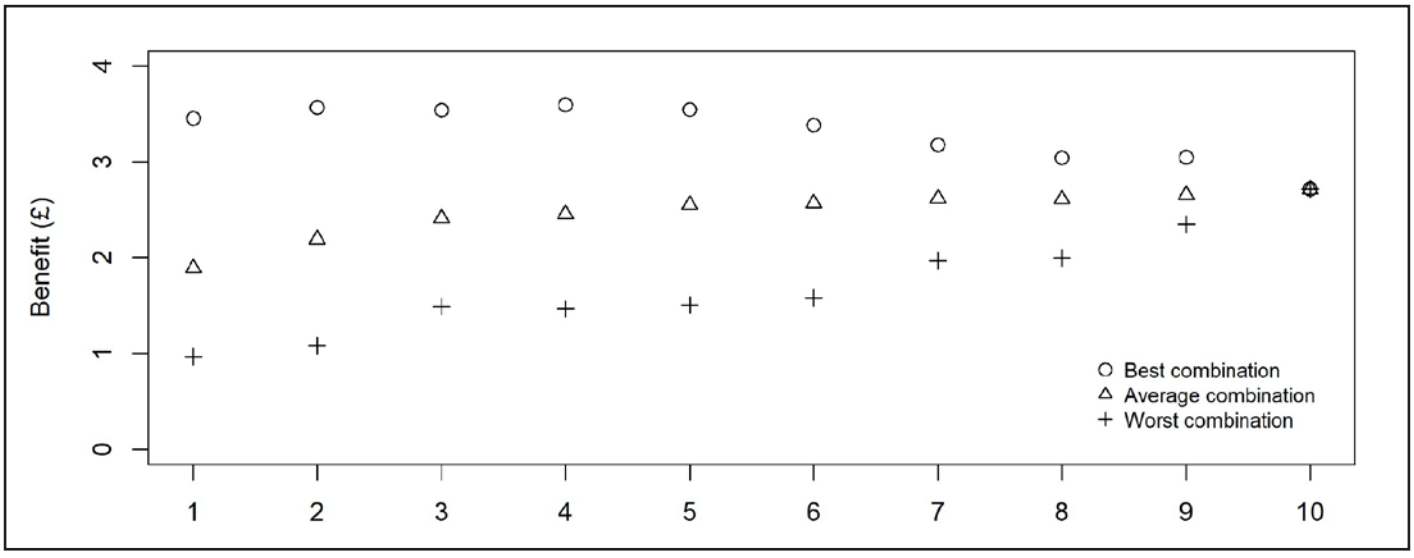
Results: Peak information benefit was identified when four predictors (ewe's weight and BCS at lambing, ewe's weight at tupping and lamb's weight at weaning) were used together (Figure 1), with an information value of £3.60 per lamb under the best combination. The inclusion of additional metrics beyond this point reduced the benefit regardless of the combination selected, signalling the risk associated with unquestioning use of KPIs. The difference between the best and worst combination of predictors was pronounced, up to £2.49 under two predictors. More importantly, large discrepancies were also observed between the best and average combination (up to £1.56 under one predictors), suggesting that predictors selected on evidence are substantially more valuable than those chosen randomly.

Conclusion: The use of KPIs selected on quantitative evidence to support on-farm decisions is far more likely to contribute to a farm's profitability than those chosen by other means. To the best of our knowledge, this is the first attempt to systematically quantify information values of livestock KPIs.

Acknowledgements: Funded by AHDB (61100030) and BBSRC (BBS/E/C/000J0100 and BBS/E/C/000I0320).

References: AHDB 2019. KPI Calculators. Better returns programme. Lima E, et.al., 2020. Preventive Veterinary Medicine 174, 104851.

Figure 1. Combined information value of multiple predictors (£/lamb).



Reducing dietary protein and supplementation with starch or rumen-protected methionine on milk performance and metabolism in dairy cows fed red clover/ grass silage based diets

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Application: The dietary protein content can be reduced from 175 to 150 g/kg DM without affecting performance when dairy cows are fed diets based on red clover/grass silage, but there is no advantage to additional starch or rumen-protected methionine. This will potentially reduce diet costs and improve nitrogen use efficiency.

Introduction: Dietary protein concentration in dairy cow diets can be reduced to around 140-150 g/kg dietary dry matter (DM) without any major impact on performance if the diets meet the cows metabolisable-protein (MP) requirements (Sinclair et al., 2014). Most studies, however, have been based on maize and lucerne silages. In our previous studies with red clover/grass silage-based diets (Chowdhury et al., 2020), reducing dietary crude protein (CP) content from 175 to 150 g/kg DM decreased DM intake without affecting milk performance, although the long-term effect on body energy reserves was unclear. The negative impact of low protein diets on cow performance can be reduced by feeding more starch to increase microbial-protein synthesis or by supplementing with rumen-protected methionine (Sinclair et al., 2014).

Material and methods: Fifty-six early lactation Holstein-Friesian dairy cows yielding 42.3 ± 6.83 kg/d were blocked according to days in milk and yield and randomly assigned to 1 of 4 diets over a 14-week study period. Treatment diets were: High protein diet (175 g CP/kg DM, C); low protein diet (150 g CP/kg DM, LP); LP supplemented with additional starch (LPS), or LP with added rumen-protected methionine (LPM). All diets were formulated to contain a similar MP content and were based on a 1:1 ratio (DM basis) of red clover to grass silage, with a forage to concentrate ratio of 0.53:0.47 (DM basis). The diets were fed as a total mixed ration. Intake and milk yield were recorded daily. Milk samples were collected and live weight measured fortnightly. Blood samples were taken during week 0, 4, 8 & 14. Performance and blood metabolite data were analysed as repeated measures ANOVA using block and diet as fixed effects and cow as a random effect in GenStat 18.1 (VSN Ltd, Oxford, UK).

Results: Dry matter intake was not affected by diet, with a mean of 21.5 kg/d, but there was an interaction between diet and time (Table 1), with intake being highest in cows fed LS in week 4 and C in weeks 9 and 14. There was no effect of diet on milk yield, milk composition or LW change, but milk and plasma urea concentrations were lowest in cows receiving any of the low CP diets compared to C, whilst plasma b-hydroxybutyrate was highest in cows fed LM and lowest in those receiving LS.

Conclusions: Dietary CP concentration can be decreased from 175 to 150 g/kg DM in a red clover/grass silage-based diet without affecting DM intake or performance, but there is no benefit to added starch or rumen-protected methionine.

Acknowledgements The authors thankfully acknowledge funding from AHDB.

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Sinclair, K.D., P.C. Garnsworthy, G.E. Mann, L.A. Sinclair. 2014. Animal 8: 262-274.

Table 1. Intake, performance and plasma metabolites of dairy cows fed diets1 based on red clover/grass silage.

	Diet[1]				SED	P-value[2]		
	C	LP	LPS	LPM		D	T	Int
DM intake (kg/d)	22.0	21.1	21.7	21.2	0.59	0.371	<.001	0.007
Milk yield (kg/d)	37.9	36.3	37.8	37.1	1.04	0.170	<.001	0.957
Milk fat (g/kg)	39.4	40.9	41.6	41.3	2.37	0.581	0.021	0.755
Milk protein (g/kg)	29.9	30.1	31.3	30.7	0.96	0.400	<.001	0.820
Milk urea (mg/dL)	20.2[a]	14.8[b]	14.4[b]	12.4[b]	1.62	<.001	0.014	0.420
LW change3 (kg/d)	0.05	0.02	0.13	0.18	0.126	0.600	-	-
Plasma urea (mmol/l)	3.62[a]	2.09[b]	2.43[b]	2.02[b]	0.267	<.001	0.008	0.304
Plasma b-hydroxybutyrate (mmol/l)	0.80[ab]	0.78[ab]	0.70[b]	0.92[a]	0.095	0.003	0.182	0.321

[1]C = high protein diet (175 g CP/kg DM); LP = low protein diet (150 g CP/kg DM); LPS = LP added with dietary starch; LPM = LP with added rumen-protected methionine;
[2]D = main effect of diet; T = main effect of time; Int = interaction between diet and time;
[3]LW = live weight, change over the 14-week feeding period;
Week 0 was used as a covariate when appropriate.
Means with different superscripts in a row differ (P < 0.05).

Determinants of phosphorus balance and use efficiency in diverse dairy farming systems

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Application: Identifying the determinants of phosphorus balance is critical for policy-makers and farm advisory services in countries operating diverse dairy farming systems to develop strategies to improve the sustainability of dairy farming.
Introduction: Information about phosphorus balance across dairy farming systems is scarce despite each system contributing to eutrophication differently (O'Brien et al., 2012). The current study aimed to identify the determinants of phosphorus balance and use efficiency across dairy farming systems in Great Britain.

Material and methods: Records to calculate phosphorus balances were collected from thirty farms across different dairy systems in Great Britain (Garnsworthy et al., 2019) or generated by quantifying phosphorus concentration in feed, manure, and soil samples collected from farms. The 'Planning for Land Application of Nutrients for Efficiency and the environmenT' tool was used to calculate farm-gate phosphorus balance and the 'Annual Nutrient Cycling Assessment' tool was used to calculate soil-surface phosphorus balance. Differences in phosphorus import, export, balance, and use efficiency between systems were investigated using ANOVA and determinants were identified using stepwise linear regressions in Minitab.

Results: Phosphorus surpluses across all systems were reflected in large soil Olsen P concentrations (Table 1). The housed system had greater phosphorus surplus and lower use efficiency than most pasture-based systems, primarily because of greater feed phosphorus import and a lower percentage of home-grown feed in the diet.

Conclusions: High phosphorus surpluses in housed systems could be largely mitigated by importing less phosphorus in concentrate feeds, whereas pasture-based systems can lower phosphorus surpluses by increasing the percentage of home-grown feeds in their herds' diet. Therefore, strategies to reduce phosphorus pollution from dairy farming in countries operating diverse dairy farming systems would benefit from a more system-specific approach.

Acknowledgements: The authors acknowledge funding from the AHDB (41110062).

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O'Brien D, Shalloo L, Patton J, Buckley F, Grainger C and Wallace M 2012. Agricultural Systems 107, 33 - 46.

Table 1: Phosphorus import, export, balance, use efficiency and soil concentration in dairy farming systems
[1]System 1 = >274 days grazing/year to System 5 = zero grazing/year (Garnsworthy et al., 2019), a-b Means in a row without a common letter differ (P < 0.05)

	Dairy farming system[1]					SE	P value
	1	2	3	4	5		
Home-grown feed in herds' diet (%)	77.2^{ab}	79.4^{a}	78.7^{a}	58.0^{ab}	48.6^{b}	0.14	⩽ 0.01
Farm-gate phosphorus feed import (kg/ha)	10.4^{b}	11.3^{b}	12.2^{b}	16.0^{ab}	37.0^{a}	10.5	⩽ 0.01
Farm-gate phosphorus balance (kg/ha)	11.2^{ab}	3.34^{b}	9.25^{b}	8.74^{ab}	24.8^{a}	7.76	⩽ 0.01
Farm-gate phosphorus use efficiency (%)	44.8^{ab}	99.0^{a}	71.0^{ab}	48.7^{ab}	46.9^{b}	33.2	= 0.02
Soil-surface phosphorus balance (kg/ha)	9.19^{ab}	2.12^{b}	5.80^{b}	7.94^{ab}	21.7^{a}	7.86	⩽ 0.01
Soil-surface phosphorus use efficiency (%)	65.8^{ab}	98.1^{a}	90.0^{a}	51.8^{ab}	46.4^{b}	21.9	⩽ 0.01
Soil Olsen P concentration (mg/kg)	33.3	44.4	49.4	32.5	42.3	19.4	= 0.71

Intake, growth and carcass traits of steers offered grass silage supplemented with barley- or oats-based rations with or without peas and beans

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Application: The feeding value of oats was comparable to barley, and beans was superior to peas. Supplementation of cereals with protein feedstuffs may be unnecessary for finishing beef cattle offered good 'quality' grass silage.

Introduction: In Northern Europe there is increasing interest in exploiting indigenous energy and protein feedstuffs. Relatively little research has been reported on oats (McGee et al., 2018), peas and beans (Halmemies-Beauchet-Filleau et al., 2018) as feed ingredients for beef cattle, particularly when used as supplements to grass silage. In terms of reducing nitrogen excretion and feed costs, it is also important to assess if protein supplements can be excluded from concentrate rations without compromising animal performance. The study objective was to determine intake and performance of beef cattle offered grass silage supplemented with barley or oats with or without peas or beans.

Material and methods: Late-maturing suckler-bred steers (n=72; 596kg, s.d. 19.8; 21-months old, s.d. 0.9) were blocked by sire breed and weight, and within block were randomly assigned to one of six supplement treatments: 1.Rolled barley (922 g/kg), 2.Rolled barley (622 g/kg) plus flaked peas (260 g/kg), 3.Rolled barley (742 g/kg) plus flaked beans (180 g/kg), 4.Rolled oats (922 g/kg), 5.Rolled oats (642 g/kg) plus flaked peas (280 g/kg), 6.Rolled oats (732 g/kg) plus flaked beans (190 g/kg). Concentrates containing peas or beans were formulated to be isonitrogenous (144 g crude protein (CP)/kg dry matter (DM)); the corresponding value for those not containing a protein ingredient was 116 g CP/kgDM. To decrease the high rumen degradable protein, peas and beans were flaked (Mendowski et al., 2021). All concentrates contained 50 g/kg molasses and were balanced for minerals/vitamins. Steers were individually offered 4 kg concentrate DM daily (in two feeds) in addition to grass silage (725 g/kgDM digestibility, 152 g/kgDM CP) ad libitum, for 146 days. Animal live weight, ultrasonic measures of muscle and fat depth, and carcass weight, conformation and fat score were determined. Data were analysed using ANOVA with terms for cereal type, protein source, their interactions and block in the model.

Results: There were no interactions between cereal type and protein source. Intake, growth, carcass weight, conformation and fat score, and ultrasonic measures of body composition did not differ between cereal type, or cereal 'protein' and beans; however, carcass weight was lower (P=0.05) for peas (Table 1). Table 1 Effect of cereal type and protein inclusion on animal intake and performance.

Conclusion: The feeding value of oats was equal to barley, and beans was superior to peas. Supplementing the cereals with beans had no effect on carcass growth, whereas supplementation with peas had a negative impact.

References:

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McGee M, Kelly M, Kelly A and Moloney AP 2018. Advances in Animal Biosciences. 9, 226.
Mendowski S, Noziere P, Ferlay A, Denis P, Chesneau G and Chapoutot P 2021. Animal Feed Science and Technology. 271, 114758.

	Cereal type				Protein source				
	Barley	Oats	SEM	P-value	Peas	Beans	Cereal	SEM	P-value
Dry matter intake (kg/day)	5.9	5.8	0.12	NS	5.8	5.8	5.9	0.14	NS
Daily live weight gain (kg)	0.64	0.64	0.027	NS	0.58	0.67	0.68	0.033	0.08
Final live weight (kg)	697	697	3.9	NS	688	701	703	4.8	0.08
Carcass weight (kg)	402	405	3.3	NS	396	405	410	4.0	0.05
Conformation score (1-15)	9.0	9.5	0.24	NS	8.7	9.7	9.3	0.29	0.07
Fat score (1-15)	7.9	7.8	0.24	NS	7.8	7.9	7.9	0.30	NS

Impact of supplementation dose and form on selenium partitioning and composition in urine and faeces of sheep

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Application: Supplementation dose is a greater determining factor than supplement form with respect to selenium retention in sheep and selenium flux in grazing pasture systems.

Introduction: Ruminant excreta provide important nutrients for growing pasture in grazing livestock systems. Additionally, with sustained interest in increasing mineral provision to ruminants through supplements, there is a need to better understand how different forms and doses of mineral supplements, which reflect different bioavailability, affect micronutrient excretion and subsequent flux within the environment. The aim of this experiment, therefore, was to determine the effects of supplementary doses and forms (organic/inorganic) of key minerals on mineral partitioning across different excretory routes in sheep. The selenium results are presented here.

Materials and methods: Concentrates containing inorganic minerals: manganese oxide, copper sulphate pentahydrate, zinc oxide and sodium selenite or organic minerals: manganese, copper, zinc chelates of protein hydrolysate, and selenised yeast (Selplex®) were given to 24 individually-penned male Charolais x Suffolk-Mule sheep offered a ration of grass silage: concentrate (60:40; DM basis of pre-determined 0.9 ad libitum silage DM intake). The concentrates with premixed minerals of 100% or 80% of typical industrial levels of inclusion (IND) were offered for two weeks, with Se offered 0.6 or 0.2 mg-Se/kg-concentrate, respectively, based on the permitted upper-level of organic Se supplement. This resulted in four treatments: organic minerals at higher (OH) or lower (OL) IND and inorganic minerals at higher (IH) or lower (IL) IND. The sheep were allocated randomly into six blocks according to their body weights, and offered silage and different treatments of concentrate in individual feeding buckets. Complete urine and faecal collection was performed separately and individually before the morning feed. The total element analysis of samples was carried out using ICP-MS. An ANOVA model (two-factor factorial design in a randomized complete block) was performed in R software to test the influence of mineral forms and supplementary dose on the response variables.

Results: More than 50% of the Se came from the supplementation as opposed to the basal diet (Table 1). The Se partitioning in urine and faeces, as well as retention, was significantly affected by supplementation dose (Table 2). Faeces was the major excretion route (Table 2) and the concentrations of Se in faeces were significantly influenced by supplementation dose (Figure 1 top). No significant impact of supplement forms was observed on the excretion and partitioning of Se, nor on that of other minerals observed (data not shown).

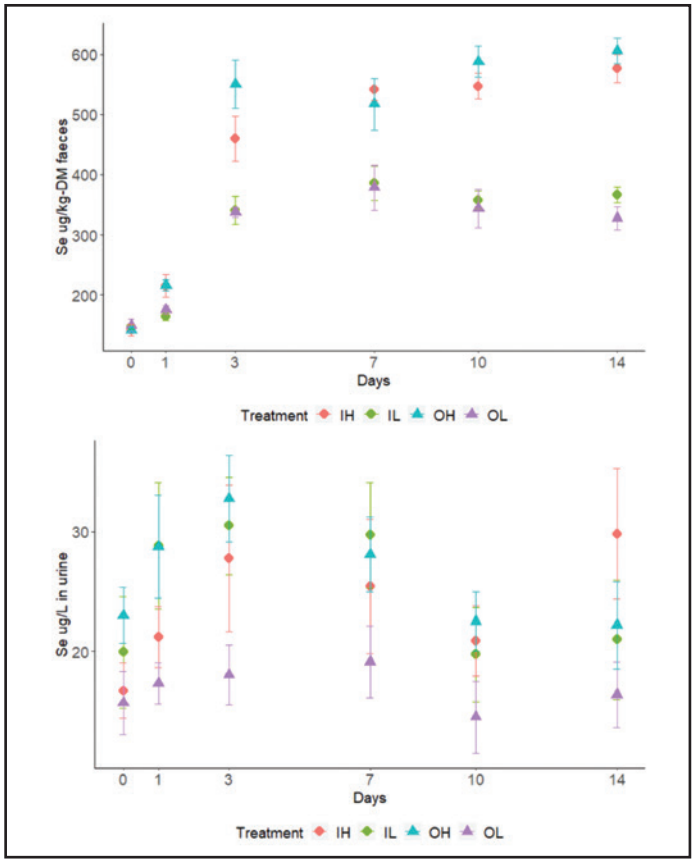
Table 1

Treatment	Silage	Background concentrate	Mineral supplement	Total intake
IL	0.022 (9%)	0.094 (38%)	0.133 (53%)	0.249
IH	0.020 (4%)	0.095 (19%)	0.391 (77%)	0.506
OL	0.021 (10%)	0.078 (37%)	0.110 (53%)	0.209
OH	0.023 (5%)	0.095 (20%)	0.368 (76%)	0.486

Table 2

Treatment	Urine	Faeces	Retained
IL	0.11 ± 0.01	0.52 ± 0.02	0.37 ± 0.02
IH	0.09 ± 0.01	0.46 ± 0.03	0.45 ± 0.03
OL	0.13 ± 0.00	0.51 ± 0.02	0.36 ± 0.02
OH	0.08 ± 0.01	0.43 ± 0.03	0.49 ± 0.02
Se forms (Pr>F)	0.9361	0.5106	0.4777
Se levels (Pr>F)	0.0010***	0.0156*	0.0004***
Forms x levels (Pr>F)	0.0638	0.8717	0.3765

Figure 1



Conclusion: Up to the regulated upper levels of organic Se supplementation, the form of supplement showed no significant effect, whereas the different doses significantly affected Se partitioning in sheep and Se concentration in faeces. This difference in output and level within faeces and urine will influence Se profiles in soil and potential environmental flux within grazing livestock systems.

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Relationships between early lactation energy balance and performance indicators, blood metabolites and fertility traits in multiparous dairy cows

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Application: Early lactation energy balance is a key driver of return to cyclicity in dairy cows, but not of conception rate.

Introduction: While the decline in dairy cow fertility in recent decades has often been linked to a greater negative energy balance (EB), many 'fertility studies' have involved relatively small numbers of cows. The current study used a large individual cow dataset collected over a 20-year period to examine the relationships between early lactation EB (days 4 – 21 in milk, generally corresponding to nadir EB), cow performance, blood metabolites, and a number of fertility traits.

Material and methods: A meta-analysis of data from 1020 Holstein-Friesian dairy cow lactations, collated from 27 experiments conducted at AFBI Hillsborough over a 20 year period, was undertaken. Cows were in lactations 2 – 6, and had dry matter intake (DMI), performance and feed composition data available from calving until a mean of 129 days in milk (DIM), thus allowing daily EB (MJ of ME/d) to be calculated for this period. Fertility data was available for all cows, while milk progesterone (to determine start of luteal activity; SLA) and periodic blood metabolite data were available for 722 and 860 lactations, respectively. The dataset was divided into quartiles (Q1 – Q4) according to the average EB during 4 – 21 DIM (Q1, -191 to -79; Q2, -79 to -48; Q3, -48 to -22 and Q4, -22 to 93 MJ/d), and differences between EB quartiles for production and fertility traits were compared using GenStat, Version 20.1 (VSN International Limited, 2019).

Results: Moving from Q1 to Q4 (increasing EB), mean DMI and milk protein content increased, while energy corrected milk yield, milk fat content, milk fat : protein ratio, plasma non-esterified fatty acid and βhydroxybutyrate concentrations decreased (Table 1). Similar significant trends (P < 0.01) were observed over days 4 – 150 DIM (data not presented), with the exception of DMI (P = 0.082). For the subset of cows for which milk progesterone data was available, interval from calving to SLA decreased from Q1 to Q4, while peak progesterone concentration at SLA increased. Days to first observed heat (FOH) decreased from Q1 to Q4, while the percentage of cows with FOH before 42 DIM increased from Q1 to Q4. For each 10 MJ/day decrease in mean EB during 4 - 21 DIM, FOH was delayed by 0.8 days. However, neither days to first artificial insemination (AI) nor the percentage of cows that conceived to first AI, were affected by early lactation EB, perhaps reflecting first AI taking place at approximately 70 DIM in all EB quartiles.

Table 1. Performance indicators (days 4 to 21 post calving) and fertility traits of cows within energy balance (EB) quartile (the latter based on mean daily EB during 4 to 21 days in milk; DIM)

	Quartiles (mean daily EB during 4 to 21 DIM)					
Item[1]	Q1 (-191 to -79 MJ/d)	Q2 (-79 to -48 MJ/d)	Q3 (-48 to -22 MJ/d)	Q4 (-22 to 93 MJ/d)	SED	P-value[2]
Performance indicators (4 – 21 DIM)						
Total dry matter intake (kg/d)	15.5^{a}	16.8^{b}	16.8^{b}	18.0^{c}	0.24	<0.001
Energy corrected milk (kg/d)	41.9^{d}	38.3^{c}	34.7^{b}	30.9^{a}	0.54	<0.001
Milk fat (g/kg)	49.6^{c}	46.0^{b}	45.3^{b}	42.6^{a}	0.58	<0.001
Milk protein (g/kg)	34.8^{a}	35.3^{b}	35.7^{bc}	36.0^{c}	0.26	<0.001
Fat : protein ratio	1.43^{c}	1.30^{b}	1.27^{b}	1.19^{a}	0.017	<0.001
Plasma NEFA (mmol/mL)	0.70^{d}	0.58^{c}	0.52^{b}	0.42^{a}	0.028	<0.001
Plasma BHB (mmol/l)	0.82^{c}	0.74^{b}	0.69^{b}	0.61^{a}	0.038	<0.001
Fertility traits						
Interval from calving to SLA	35.7^{b}	29.4^{a}	31.0^{a}	29.8^{a}	1.29	0.003
Peak progesterone conc. at SLA (ng/mL)	24.4^{a}	25.9^{ab}	27.4^{b}	28.1^{b}	2.14	0.026
Cows with SLA pre day 42 (%)	70 (59-80)	83 (75-90)	78 (68-86)	79 (69-86)	-	0.103
Days to FOH	49.0^{b}	44.9^{ab}	42.9^{a}	41.6^{a}	2.07	0.012
Cows with FOH pre day 42 (%)	41 (29-53)	49 (38-61)	55 (43-66)	58 (46-69)	-	0.038
Days to first AI	72.7	69.9	68.9	68.6	3.04	0.557
Conception to first AI (%)	28 (22-35)	29 (24-36)	26 (21-33)	33 (26-40)	-	0.672
Genetic traits						
Profitable lifetime index (£PLI)	-64.9	-55.8	-43.4	-39.2	11.23	0.140
PTA milk (kg)	40.6a	45.2ab	55.8b	58.7b	6.83	0.048
PTA fertility	-0.5	-0.7	-0.5	-0.5	0.17	0.270

[1]NEFA= non-esterified fatty acids; BHB= β-hydroxybutyrate; FOH= first observed heat; SLA= start of luteal activity; PTA= Predicted transmitting ability; [2]Values within a row with different superscript differ at P < 0.05; Binomial data, upper and lower confidence limit in parenthesis.

Conclusion: While interval from calving to SLA and to FOH were reduced with improving EB in early lactation, conception rate to first AI was unaffected by early lactation EB.

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Metabolomic changes in Mycobacterium avium subsp. paratuberculosis (MAP) inoculated Holstein-Friesian cattle suggest metabolites indicative of MAP exposure

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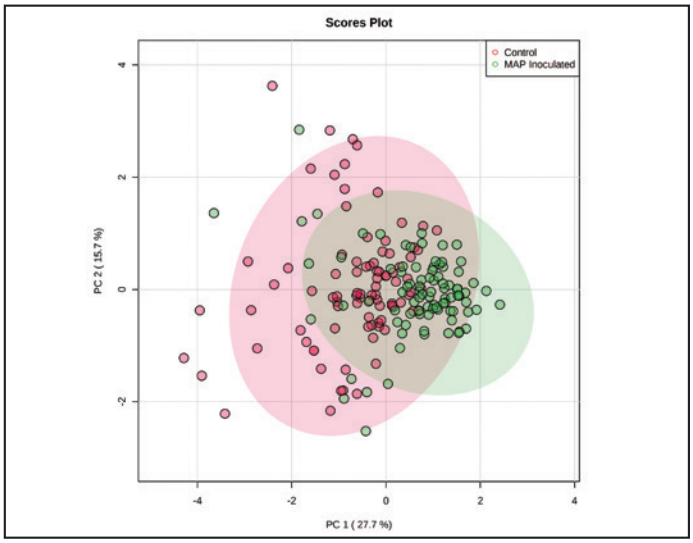
Application: Identified metabolites successfully differentiated between Mycobacterium avium subspecies paratuberculosis (MAP) inoculated and control cattle during the incubation stage of infection. If validated, these metabolites would enable farmers to identify MAP exposed cattle before shedding or clinical signs develop.

Introduction: Paratuberculosis, commonly known as Johne's disease, is a chronic intestinal infection of ruminants, caused by MAP. Clinical signs, including reduced milk yields, weight loss and diarrhoea, are typically absent until 2 to 6 years post-infection (Salem et al., 2012). This study aimed to examine the effects of MAP inoculation on the metabolomic profile of serum from Holstein-Friesian cattle and correlate affected metabolites to haematological parameters.

Material and methods: At approximately 6-weeks of age, 35 calves received an inoculation with MAP (clinical isolate CIT003) 3.8 x 109 on 2 consecutive days. An additional 20 calves formed the control group. Cattle were housed indoors in two separate buildings 500 metres apart, according to their inoculation status. Serum samples were collected pre-, 2-, 3-, 6-, 10-, 12-, 16-, 20-, 24-, 28-, 31- and 33-months post MAP inoculation. Cattle were euthanised 12-, 24- or 33- months post MAP inoculation. Sera from 18 cattle euthanised 33-months post MAP inoculation were utilised. Sera were assessed using flow infusion electrospray high resolution mass spectrometry on a Q Exactive hybrid quadrupole-Orbitrap mass spectrometer for high throughput, sensitive, non-targeted metabolite fingerprinting. Following principal component analyses (PCA), time series analyses used false discovery rate adjusted two-way ANOVA tests to identify mass-ions (m/z) which significantly (p-values < 0.05) differed between experimental classes. Correlation analysis between the identified metabolites and haematology parameters, including erythrocytes, lymphocytes and monocytes, was performed using Pearson's correlation coefficient. Metabolites were identified using the DIMEdb database of metabolites for Direct Infusion/Injection Metabolomics (https://dimedb.ibers.aber.ac.uk/) based on their mass-ion (m/z) values.

Figure 1: PCA for MAP inoculated and control cattle in the negative ionization mode. The light red and green ellipses represent 95% confidence intervals.



Results: PCA of the metabolomes discriminated between MAP inoculated and control cattle (Figure 1). Repeated measures ANOVA highlighted the effect of time on metabolite levels. These results were reinforced by area under the curve (AUC) assessments which indicated that identified metabolites represented sensitive and specific changes occurring at discrete time points. Metabolite set enrichment analysis (MSEA) using over representation analysis (ORA) demonstrated that phosphatidylcholine biosynthesis was significantly affected by MAP inoculation (P<0.05). Additionally, significant correlations were seen between identified metabolites, such as 2-oxosuccinamate, and haematology parameters, particularly monocytes (%) (P<0.05) (one example is given in Figure 2).

Conclusion: Metabolomic analysis showed clear differentiation between MAP inoculated and control cattle, in addition to significant correlations between selected metabolites and haematological parameters. Future work could include assessing the relative accumulation of these metabolites in lactating dairy cattle.

Acknowledgments: The authors acknowledge funding from KESS2 and ProTEM Services Limited.
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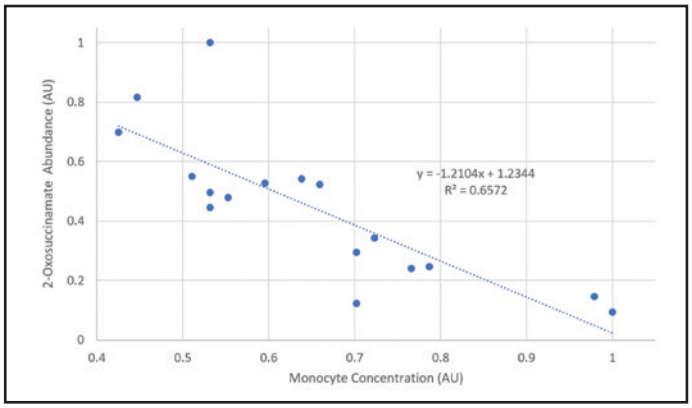
Figure 2: Correlation between monocytes and 2-oxosuccinamate 33-months post MAP inoculation.



Dietary protein and energy requirements of Japanese quails in the tropics

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Applications: Dietary protein and energy are the most important nutrients in poultry diets. There is lack of information on dietary standard for tropical Japanese quails; this is a major obstacle to the growth and productivity of Japanese quails in the tropics. This study is aimed at determining the dietary energy and protein for optimal performance of Japanese quails in Nigeria.

Introduction: Quails is one of the poultry species of economic importance, they produce eggs and meat that are enjoyed for their unique flavour (Nasrollah, 2008). They have low maintenance cost, short generation and resistance to diseases. However, the nutritional requirements of this bird for the tropical region have not been well established. Studies have shown that the nutritional needs of poultry birds vary from species to species and from one location to another. Presently, in Nigeria, the diets fed to quails are mostly based on 20 to 24% crude protein rcommended for the temperate(NRC, 1994). Furthermore, there are variations in the nutrient requirements reported for this bird (Attia et al., 2006 and Abbasali et al., 2011). Thus, determining the optimal dietary protein, energy and their interaction on the productivity of Japanese quails is the justification for this work.

Materials and methods: A total of 576 unsexed Japanese quails aged two weeks were used for this experiment. A 4 (dietary energy levels: 2600, 2800, 3000 and 3200 Kcal metabolizable energy) x 4 (dietary crude protein levels: 20, 22, 24 and 26 %) factorial arrangement in a completely randomized design (16 experimental units). Sixteen soya beans-based mash diets were formulated and compounded according to the design of the study. Data on body weight, feed intake were measured and were used for calculating the body weight gain, and feed conversion ratio. All data collected were subjected to a two-Way Analysis of Variance using SAS statistical package (SAS, 2019). Standard and procedure of the Federal University of Technology, Minna, Nigeria ethical guide line was strictly followed.

Results: The results of the main effect of different dietary protein and energy levels on the growth performance of Japanese quails are presented in Table 1. In all the performance parameters measured, there was no significant ($p>0.05$) differences observed in the treatment groups, thus no interaction.

Conclusion: Since there was no difference in all the parameters measured, in order to save feed cost, it is more economical to use the lowest protein and energy levels. It is, however, recommended that the same diets should be fed to laying birds to determine the requirements for optimal egg laying performance and quality.

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NRC (1994). Nutrient Requirements of Poultry (9th Ed.). National Academy Press, Washington, DC.

Table 1: Main effect of dietary protein and energy on performance of Japanese Quails

Treatments	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Total fed Intake (g)	FCR
Effect of crude protein (%)					
20.00	20.23	84.16	63.94	892.89	2.00
22.00	20.27	84.83	64.56	893.01	1.98
24.00	20.25	84.63	64.38	915.44	2.02
26.00	20.24	84.06	64.82	903.16	2.04
SEM	0.02	0.66	0.65	20.92	0.06
p. value	0.81	0.81	0.83	0.85	0.93
Effect of energy ME/Kcal)					
2,600	20.26	83.91	63.65	928.44	2.04
2,800	20.24	84.14	63.90	926.41	2.07
3,000	20.24	84.94	64.70	883.61	1.96
3,200	20.26	84.53	64.27	865.95	1.94
SEM	0.03	0.66	0.65	20.92	0.06
p. value	0.86	0.71	0.70	0.12	0.34

Lower feed quality does not impact on the nutritional composition of Tenebrio molitor

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Application: Reducing feed quality and altering the environment of Tenebrio molitor (yellow mealworm) appears not to effect composition, indicating environmental and financial savings are possible.

Introduction: Tenebrio molitor larvae (TM) production methods and feed sources need to be sustainable for it to be an effective replacement feed ingredient. For small-scale producers, the relatively high-quality feed, chick crumb, is a common feed. However larger-scale producers commonly use lower quality wheat bran as a feed. This study compared the effects of feeding wheat bran or chick crumb in different environments on TM production and nutritional composition.

Materials and Methods: TM (mini form) were obtained from Monkfield Nutrition Ltd and acclimatised for 3 days on wheat bran. The feeds utilised were either wheat bran (WB) or 20% chick crumb (CC) feed (Dale et al., 2020). Two dark locations were used, an insect incubator (25±1°C, 60% relative humidity) or a room (18.5±3.5°C, 40±3% relative humidity). On day 0, TM were transferred to plastic containers (n=200/container) and allocated to one of four treatment groups: WB-I (WB in incubator), WB-R (WB in room), CC-I (CC in incubator) and CC-R (CC in room). TM were fed ab libitum, with feed and water consumption measured and refreshed on days 4, 7 and 11. On day 14, final measurements were recorded and any dead removed. After killing by cold exposure, samples were freeze dried and analysed for crude protein (EA1112 Elemental Analyser), total fat (Gerhardt Soextherm) and total energy (Bomb Calorimeter). Data were analysed by two-way (feed x location) ANOVA using Genstat (19th Edition). When significant ($P<0.05$) a post-hoc Bonferroni test was carried out.

Results: There were no significant differences in initial or final group live weights, dry matter, crude protein, total fat or total energy of the TM (Table 1). Total feed intake was significantly lower in the groups fed in the room, with the WB-R group the lowest. No differences in final live weights suggests that WB-R TM were the most feed efficient.

Table 1: Effects of feeding chick crumb (CC) or wheat bran (WB) for 14 days in an incubator (I) or room (R) on TM production and composition.

	WB-I	WB-R	CC-I	CC-R	SED	P Value
Initial Live Weight (g)	12.56	12.42	12.65	12.66	0.439	0.801
Final Live Weight (g)	18.27	19.19	19.53	20.19	0.785	0.817
Total Feed Intake (g)	39.37^{a}	31.29^{b}	38.82^{a}	34.76^{c}	0.622	<0.001
Dry Matter (gDM)	7.10	6.81	7.67	7.69	0.449	0.642
Crude Protein (g/gDM)	0.50	0.49	0.48	0.48	0.016	0.671
Total Fat (g/gDM)	0.26	0.24	0.24	0.22	0.014	0.660
Total Energy (MJ/gDM)	0.024	0.024	0.024	0.24	0.0003	0.838

Conclusion: With no composition differences both CC and WB were equally suitable as feeds, but WB would be more cost effective and sustainable. Further work is needed to define TM production for optimal environmental and financial benefit.

Acknowledgments: The work was gratefully supported by funding from AB Agri, AB Vista and BBSRC.

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Multiple model triangulation increases confidence in the findings we can present to sheep farmers

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Application: Epidemiology helps to uncover how real-life farm practices are linked to disease transmission on farm, using statistical models from real life data. Triangulation of multiple models is a more recent concept to address the impact of sources of bias in these models.

Introduction: A central tenant of statistical modelling is "all models are wrong, but some are useful" (George Box). Statistical models created from questionnaire data can be translated into real-life recommendations, to improve control of lameness in sheep. One challenge is to ensure recommendations are 'true' rather than 'spurious' and so will have impact. False positive associations can be reduced via use of triangulation, where results are compared between multiple model types. Triangulation is currently rarely applied in veterinary epidemiology, but was used here to identify a robust set of predictor variables likely to produce reliable recommendations to reduce lameness in sheep flocks.

Materials and methods: In 2018, a cross-sectional survey was sent to 3200 sheep farmers in Great Britain, with 523 returned and 310 usable. The prevalence of lame ewes and lambs and management practices over one year were reported.

Four model types were chosen – two generalised linear models (quasi-Poisson and negative binomial) and two bootstrap regularised regression models (Poisson and Gaussian) incorporating selection stability (the percentage of times a covariate is selected by the automatic feature selection in the elastic net models). Explanatory variables consisted of 57 categorical covariates, dummy-coded for the elastic net models into 105 binary covariates.

Models were compared, covariates in the generalised linear models were defined as selected when $p<0.05$ (Wald's test) and in the bootstrap models when $p<0.05$ (bootstrap p-value) and with a selection stability >80%.

Results: There were 8-24 covariates selected per model of ewes, and 16-25 per model of lambs. Only 3 and 5 covariates were in all four models for ewes and lambs respectively (Table 1). Higher prevalence of lameness in ewes was associated with 5-100% of sheep feet bled during routine foot trimming and a lower prevalence of lameness in ewes was associated with no lame sheep to treat. Peat soil was associated with lower prevalence of lameness in both ewes and lambs, and prevalence of lameness in lambs was also associated with other environmental effects (Scotland, and altitude). Other covariates associated with higher prevalence of lameness in lambs were footbathing to treat interdigital dermatitis and where replacement ewes were not consciously selected from those that were never lame.

Conclusion: We conclude that this small subset of covariates is the most likely group to influence the prevalence of lameness on sheep farms because they have been identified using multiple model types which reduces the likelihood of "spurious" associations.

Acknowledgements: Funding came from BBSRC and AHDB and we would like to thank the sheep farmers for their responses.

Ewes			Lambs		
Covariate		**Risk ratio***	**Covariate**		**Risk ratio***
Time to treatment of ewes with footrot	0-3 days	Ref	*Footbath used to treat interdigital dermatitis*	No	Ref
	>3 days			Yes	1.64 (1.25-2.17)
	None to treat	0.07 (<0.01-0.41)	*Country*	England	Ref
% sheep feet bled during routine trim	Did not trim	Ref		Scotland	0.52 (0.35-0.75)
	0			Wales	
	>0-<5		*Predominant soil type - peat*	No	Ref
	5-100	1.31 (1.13-1.51)		Yes	0.53 (0.35-0.78)
Predominant soil type - peat	No	Ref	*Selection of replacements from ewes that were never lame*	Yes	Ref
	Yes	0.77 (0.65-0.90)		No	2.07 (1.47-2.92)
				Unknown	
				None replaced	
			Maximum altitude flock was grazed at (m above sea level)	0-231	Ref
				>231-500	0.49 (0.31-0.78)
				>500-850	
				>850-1200	
				>1200-3400	
				(Missing)	

*Risk ratios/coefficients were similar across all models. Example risk ratios are given from the quasi-Poisson general linear models.

Table 1: Management practices and prevalence of lameness in either ewes or lambs in all 4 model types.

Preliminary results from the use of simulation to investigate the association between periparturient and early lactation health events and reproduction in dairy cattle

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Application: Periparturient and and early lactation events have been associated with impaired fertility at a lactation level. Use of this simulation model demonstrated that these events are unlikely to have a substantial impact on herd level reproduction under most typical farm scenarios.

Introduction: Probabilistic sensitivity analysis (PSA) draws values for inputs from probability distributions and uses simulation to explore the interrelationship between sets of inputs and outputs. PSA is increasingly used in veterinary population studies where an increasing amount of data is available. Since reproduction at a herd level has complex inputs, PSA can be used to rationalise their importance and provide information for decision makers attempting to rank various options for herd improvement and investment. This study evaluated events affecting cows at parturition and early lactation relative to other factors.

Material and methods: A simulation model was constructed using input values drawn from uniform distributions considered plausible for UK herds. Explanatory variables that were associated with pregnancy in consecutive 7-day risk periods in an existing logistic regression model were used as input parameters for each simulated lactation. The probability of pregnancy was calculated in each 7-day risk period to either pregnancy or 300 days in milk and was then adjusted to account for background herd submission and conception rates, and a draw from a binomial distribution used to determine whether or not pregnancy occurred. The model was used to simulate 500,000 herds, each of 500 lactations. Whether the cow became pregnant, and if so the days in milk at which this occurred were stored. For each simulated herd, the input values and the 21-day pregnancy rate (as an outcome) were stored. High density scatterplots and Spearman rank correlation coefficients illustrated association between outcome and each input. A multiple regression model was used to partition variance in 21-day pregnancy rate between herd input parameters. A tornado plot illustrated the predicted change in 21-day pregnancy rate when changing each input from median to upper quartile of its distribution.

Results: Partition of variance results show that a much larger proportion of variance was explained by submission and conception rates than by periparturient and early lactation events (Table 1). Changing to upper quartile submission and conception rates had a much larger impact on herd 21-day pregnancy rate than changes to periparturient event distributions (Figure 1). Of these, endometritis had the largest impact (0.358% increase).

Figure 1: Predicted effect of an equivalent increase in each input parameter on overall fertility

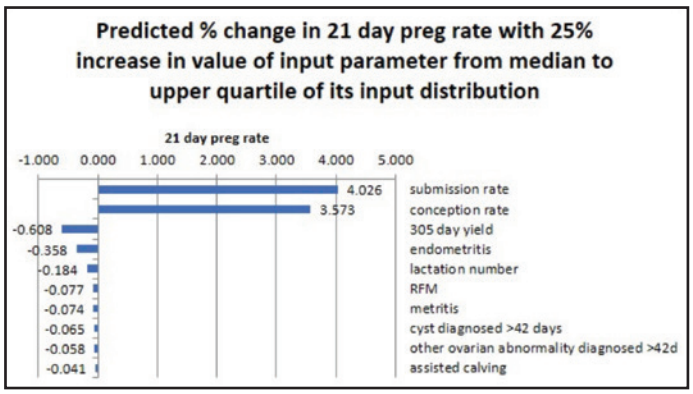

Table 1: Regression model output and partition of variance in 21-day pregnancy rate between input parameters

Input parameter	Regression coefficient	Standard Error	% variance explained
Lactation Number	-0.00812	0.000203	0.0147
Assisted Calving	-0.0149	0.000651	0.00478
Retained Foetal Membranes	-0.0266	0.000592	0.0184
Vulval Discharge <21days	-0.0316	0.000649	0.0216
Vulval Discharge >21days	-0.0594	0.000269	0.447
Cyst >42days	-0.0573	0.00124	0.0196
Other Ovarian Abnormality >42days	-0.0919	0.00226	0.0150
305-day Yield	-4.10E-06	1.14E-08	1.18
Submission Rate	0.275	0.000114	52.9
Conception Rate	0.360	0.000171	40.4

Conclusion: The association between herd periparturient and early lactation events and herd reproductive performance is strong but of a small effect size despite strong associations and effects between the events and reproduction at a lactation level. This simulation model could be supplemented to assess the association between further herd level inputs and reproduction and may ultimately allow farmers to rank alternative investments that could improve their herds.

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Predicting milk quality traits in dairy cows from routinely available milk spectra using machine learning methods.

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Application: Improved prediction of milk quality traits, however small, is useful for the milk processing industry to discriminate milk at the pre-processing stage enabling milk to be used for the process for which it is most suited.

Introduction: Mid-infrared spectroscopy (MIRS) is a tool widely used to predict the concentration of individual milk components and thanks to its characteristics (low cost, rapid and non-disruptive technique) it is used for collecting vast quantities of data at a (cow) population level. Partial least squares regression (PLSR) is the most popular method to relate MIRS data to novel milk and cow traits. In recent years, statistical machine learning (ML) methods have emerged as useful tools for prediction purposes in animal science. The novelty of the present study is the evaluation of modern statistical ML methods in predicting several cow milk quality traits from MIRS.

Material and methods: Milk samples from 622 individual cows were collected across 12-month period from 7 different Irish research herds. The milk technological traits of rennet coagulation time (RCT), curd firming time (k20), curd firmness at 30 and 60 minutes (a30, a60), casein micelle size (CMS), pH, and heat stability as well as milk protein traits including alpha s1 casein, alpha s2 casein, beta casein, kappa casein, alpha lactalbumin, beta lactoglobulin A, and beta lactoglobulin B were quantified for each milk sample using gold standard methods. All samples were analysed by the same MilkoScan FT6000 to generate 1,060 transmittance values and high-noise-level regions were removed from each spectrum. Eleven regression-based approaches were tested, such as PLSR, ridge regression (RR), least absolute shrinkage and selection operator (LASSO), elastic net, principal component regression, projection pursuit regression, spike and slab regression, random forests, boosting decision trees, neural networks (NN) and a novel post-hoc model averaging (MA) approach. The root mean square error (RMSEV) of a four-fold cross-validation was used for method comparison and the coefficient of determination (R2) was used to assess method accuracy.

Results: PLSR was the best prediction method for only pH; MA was the best prediction method for 5 of the 14 traits investigated. NN and RR were the best methods for 3 traits each, while LASSO was best for 2 traits. The well-established PLSR-based method performed competitively; nonetheless, ML methods led to a reduction in the RMSEV from between 0.18% (kappa casein) to 3.67% (heat stability). Although the ML methods investigated here slightly improved predictions over PLSR, the accuracy of the traits prediction remained moderate to low, with an R2 between 0.08 (CMS) to 0.65 (pH) for milk technological traits and between 0.19 (beta lactoglobulin A) to 0.47 (alpha s1 casein) for milk proteins.

Conclusion: The application of statistical ML methods improved the prediction of almost all milk traits. The MA approach had the lowest RMSEV most often and thus should be considered for such analyses.

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The health and behavioural effects of individual versus pair housing of calves at different ages on a UK commercial dairy farm

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Application: Housing pre-weaning dairy calves in pairs from birth or three weeks of age has no detrimental effects on health or growth compared to housing individually.

Introduction: Housing management has a large impact on rearing dairy calves, with approximately 60% of UK herds using individual pens (Marcé et al,2010). More recent studies on calf learning have demonstrated the importance of social facilitation, especially with ingestion of more solid feeds (Babu et al,2004). Much of the evidence supporting pair housing calves originates from studies feeding large volumes of milk, and housed under different environmental conditions to those in the UK. The aim of this study was to establish the effect of individual and pair housing at different ages on a UK commercial dairy farm, under conditions representative of the UK dairy sector.

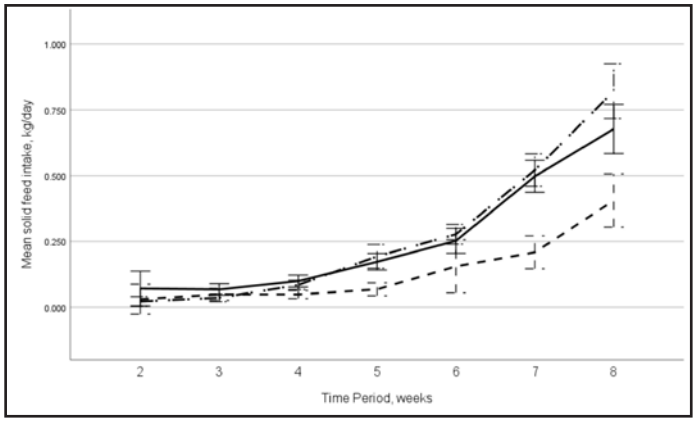
Material and Methods: This study was conducted on a single commercial dairy farm in England. A total of 100 heifer calves were recruited from March to August 2020. All calves were housed in calf hutches from 0-8 weeks of age. Pair housed calves were housed with two hutches per pair. Calves paired at three weeks of age where initially housed in individual hutches, which were then combined by removal of a gate in the outdoor area.

Each calf underwent a weekly visit for 10 consecutive weeks. At each visit the weight was measured, and a clinical health assessment was made. The solid feed was also weighed on two consecutive days each week to measure intakes.

The average daily liveweight gain (ADLG) and feed intakes were analysed using linear mixed effects models. Disease occurrence was analysed using binary logistic generalised estimating equations.

Results: One hundred Holstein heifer calves were recruited, with two calves dying. The ADLG was 0.66±0.098kg/day and was not affected by housing group (F2,274=0.30;P=0.74,Table 1). The housing group did have a significant effect on the amount of concentrate feed ingested by the calves (F2,566=4.56;P=0.011), with pair housed calves consuming more.

Figure 2: Mean measured concentrate feed consumption between visits at 2 to 8 weeks for the different housing groups of calves, with the 95% confidence interval error bars. The - - line indicates the individually housed calves (n=19 calves), the -.-.- line indicates the calves paired at birth (n=40 calves), and the ____ line indicates the calves paired at three weeks (n=38 calves).



A total of 38 calves (39.1%) experienced disease during the pre-weaning period, with a cough and diarrhoea being the most common presenting clinical signs. There was no significant effect of housing group (P=0.98).
Conclusion: This study found that within UK commercial dairy management systems, there is no detrimental effect of housing calves within pairs (either from birth or three weeks of age) compared to individual housing. There was also an increase in solid feed intakes in pair housed calves.

Acknowledgements: Research was funded by the Barham Benevolent Foundation.

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Table 1. Average daily liveweight gain of the calves over the different time periods for the three different housing groups, with the standard deviation.

	Average daily liveweight gain (± sd), kg			
	Individual	Pair housed from birth	Pair housed at 3 weeks	Average across all calves
Period 2 – 4 weeks	0.46 ± 0.13	0.45 ± 0.17	0.47 ± 0.14	0.46 ± 0.15
Period 5 – 7 weeks	0.71 ± 0.17	0.72 ± 0.17	0.74 ± 0.23	0.73 ± 0.21
Period 8 – 10 weeks	0.72 ± 0.21	0.78 ± 0.22	0.86 ± 0.23	0.80 ± 0.22
Average over pre-weaning period	0.63 ± 0.07	0.65 ± 0.09	0.69 ± 0.11	

Estimation of milk yield based in udder measures of Pelibuey sheep using artificial neural networks (ANN)

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Application: The implementation of ANN to Pelibuey sheep data using udder measures as input allows an adequate estimation of milk yield opening the possibility of using image-data in the future.

Introduction: Pelibuey sheep is a hair breed widely distributed in Central America countries, principally reared in tropical regions (Espinosa-Mendoza et al. 2020). This breed is mainly focused to produce meat; however, recently has been an increasing interest in using sheep´s milk to produce high-quality dairy products. Udder measures have been used to estimate milk yield of sheep through classical methods of estimation (Arcos-Alvarez et al. 2020). ANN is capable to deal with complex non-linear relationships between input and output variables, with no need for rigid a priori models. In the current study ANN were applied to udder measures from Pelibuey ewes to estimate their milk yield and compared with predictions from the classical linear regression.

Material and methods: A total of 357 milk yield records with its corresponding gland udder measures was used in the present study. Ewes were milking manually once a day and udder measures were recorded twice a week. Following udder measures were taken before and after milking: udder circumference (UC), udder width (UW), udder height (UH), teat length (TL), diameter of the teat (TD) and udder volume (UV). A supervised learning was used to train and teach the network using a two-layer ANN with 10 neurons each one (Figure 1). The globally convergent algorithm based on the resilient backpropagation was used to calculate ANN in neuralnet package (Fritsch et al., 2019) in R software. The fit of ANN was compared with the best multiple regression model (MRM) fitted previously by Arcos-Alvarez et al. (2020) using same input variables in both models. Goodness of fit was evaluated using the mean square prediction error (MSPE), correlation between actual and predicted values (r) and Akaike´s Information Criterion (AIC).

Results: ANN showed better estimations of milk yield in comparison with MRM. Lower values of MSPE (0.008 vs. 0.013) and AIC (-1629.01 vs. -507.22) were observed to ANN. The r value was higher in ANN (0.87) than in MRM (0.79).
Figure 1. Architecture of used ANN with two-layers and 10 neurons to estimate milk yield (MY) and initial udder circumference (CI), final udder heigh (FH), initial udder width (IW), final udder width (FW), and difference initial and final udder volume (VDF) as input variables.

Conclusion: The study reveals that ANN is a powerful tool to estimate milk yield when udder measures are used as input variables and showed better goodness of fit in comparison with classical regression methods.

Acknowledgements: Authors are grateful to Mexican Ministry of Education for funding this research Project under grant UAEH-PTC-823.

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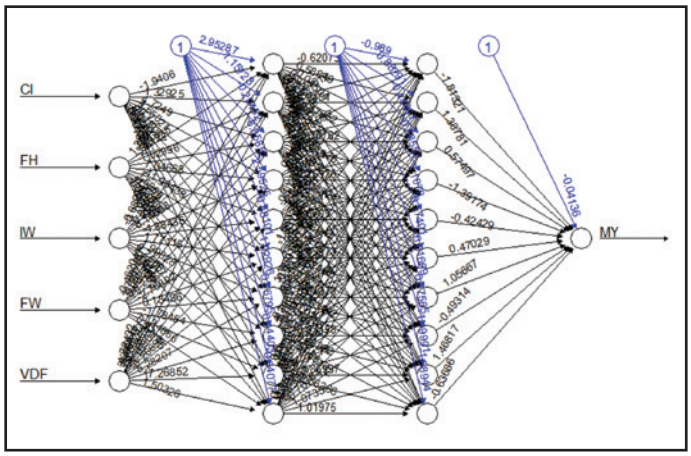
Fritsch S, Guenther F, Wright MN 2019. neuralnet: Training of Neural Networks. R package version 1.44.2.

Image 1



Effects of regrouping of Scottish Holstein-Friesian cows on milk production, physical activity, rumination time and cortisol concentration in a robotic milking system

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Application: Farmers should be aware that switching primiparous cows between groups may cause a short-term milk yield drop, and a significant decline in milk fat in all cows.

Introduction: In the commercial dairy industry, cows are commonly regrouped. Regrouping of unfamiliar animals poses animals to a new social environment which may negatively influence their welfare. Consequently, animal welfare impairment can induce negative effects and may lead to a reduction in milk production (Hasegawa et al., 1997). We investigated whether regrouping altered dairy cows' physical activity, rumination time and impacted on their stress levels, milk yield and quality in a robotic milking system.

Material & Methods: Fifty-two lactating cows (n = 17 primiparous; 35 multiparous) were moved in groups of 3-5 individuals into established pens of approximately 100 cows. Average daily milk yield (ADMY), fat and protein, physical activity and rumination time data were extracted from the Lely T4C management program for 4-time blocks (day-prior (d-1), day-of regrouping (d0), day-after (d+1) and 6-days after (d+6) regrouping) and milk samples were collected for cortisol concentration analysis. Linear Mixed Effect Modeling ('NLME' package) in R was used to determine the effect of the regrouping on milk yield, fat, protein, water, dry matter, gross energy (GE), cortisol, activity and rumination time as the dependent variables; with regrouping days, parity and their interaction as the fixed effects.

Results: Neither regrouping nor parity statistically influenced dry matter, water content, GE or cortisol concentration (P > 0.05). Primiparous cows produced (3.80±2.42 kg (12.2%), P = 0.006) less ADMY on d+1 compared to baseline level, whereas multiparous cows did not change ADMY (Figure 1C). Fat % decreased significantly for both groups following regrouping and remained low up to d+6 (Figure 1D), but a decrease in protein was only detected on d+6 compared to d-1 in both groups. Activity in both primiparous and multiparous cows increased significantly on d0 compared to d-1 (Figure 1A). Multiparous cows significantly decreased their time spent ruminating on d0 compared to d-1, but the values returned to baseline by d+6 (Figure 1B).

Conclusion: This study indicated that whilst regrouping increased activity and decreased rumination time, it only negatively affected the milk production of primiparous cows in the short term and a long-term drop of over 0.2% in fat content in both parities. There was no impact on ADMY in multiparous cows and it did not influence the stress responses in both parities. Multiparous cows may therefore benefit from previous experience.

Acknowledgements: The authors acknowledge funding from CSC UK.

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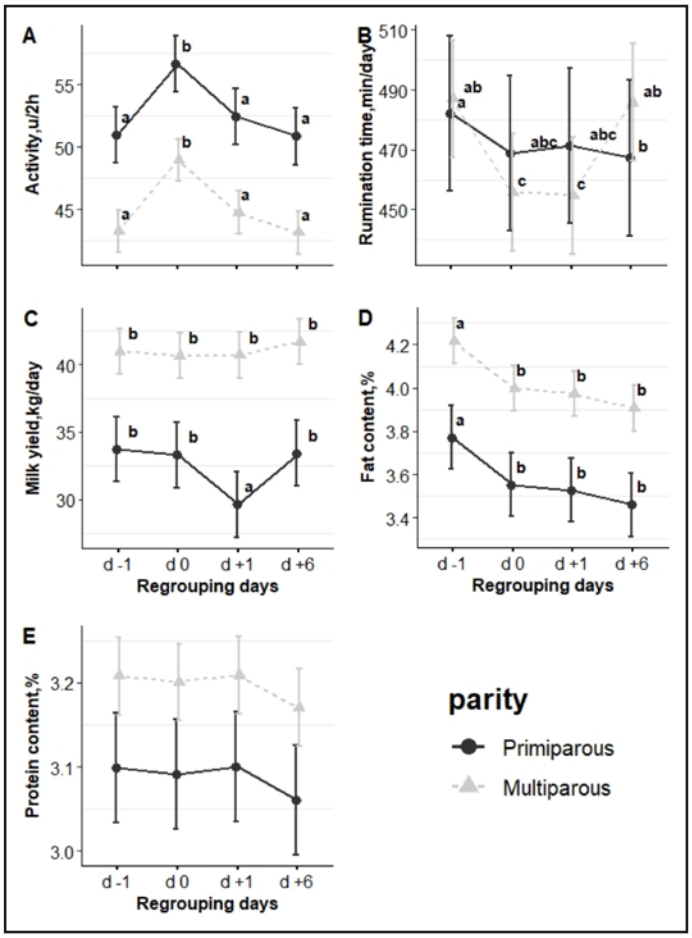

Figure 1: Least square means (±SEM) of the physical activity (A), rumination time (B), average daily milk yield (C), fat (D) and protein (E) (n = 52) of the cows during the experimental study periods. The plot illustrates the effect of regrouping (represented by the days relative to the regrouping in the x-axis) and parity. a,b,c superscripts represent a significant difference (P < 0.05) between the regrouping days and within parity.

Bovine ischaemic teat necrosis: results from a farmer-based questionnaire

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Application: Bovine ischaemic teat necrosis (ITN) is an emerging disease affecting dairy cattle (Bos Taurus) in the UK. ITN affects the teats of dairy cattle often leading to premature culling and thus is of great concerns for animal welfare, food security and economics.

Introduction: Bovine ITN was first reported in the UK in 2004 (Blowey, 2004). Since then the disease has become more widespread and has been associated with the infectious bacteria that cause bovine digital dermatitis (Clegg et al., 2016). There have been no previous national investigations into the prevalence or risk factors associated with the disease. This study presents the farmer-reported prevalence and farm-level risk factors obtained from a national postal questionnaire.

Materials and Methods: A questionnaire was submitted to 1855 UK dairy farmers in January 2018. The survey contained a series of questions investigating farmer experience with ITN and generic questions on farm environment, management and disease factors. Responses were inputted into a database; descriptive statistical investigations were applied and Chi squared test was used to assess the differences between groups. Both univariable and multivariable analysis were carried out using logistic regression. All analysis was performed in R studio (R version 3.6.1).

Results: 234 farmers adequately completed the survey to give a usable response rate of 12.6% (95% CI: 11.1-14.2%). There was no difference in response rate per country and all parts of the UK reported cases of ITN. Fifty-one percent of farmers reported having had a case of ITN with 46.3% (95% CI: 36.7-56.2%) of these farmers seeing the first case in the period 2015-2018. The first lactation animals were most affected with 47.3% (95% CI: 38.7-55.9%) of all reported cases and 78.9% (95% CI: 75.2-82.6%) of cases occurring in the first 90 days in milk. Three different clinical outcomes were reported with 20.8% (95%CI: 15.9-26.4%) of ITN cases recovered; 56.4% (95% CI: 50.0-62.6%) developed complications such as the loss of the teat or developing mastitis; and 22.8% (95%CI: 17.8-28.5%) were culled due to ITN. The cost for the different clinical outcomes were estimated to be: £720, £859 and £2992 respectively.

Multivariable logistic regression model found that the presence of udder cleft dermatitis (UCD) and chapped teats on the farm were significantly associated with the presence of ITN on the farm (Table 1).

Conclusions: Bovine ITN is widespread across the UK with first lactation animals in the first 90 days in milk most at risk of disease. Only 20.8% of cases are reported to recover and 22.8% of cases require culling due to ITN. The remaining cases develop complications. Potential farm level risk factors for ITN are cases of UCD and chapped teats on the farm.

Acknowledgements: BBSRC and AHDB for funding this study; farmers for returning questionnaire and allowing use of data; ADHB dairy for database access.

References: Blowey, R., 2004. Vet Rec 154, 214.; Clegg, S.R., Carter, S.D., Stewart, J.P., Amin, D.M., Blowey, R.W., Evans, N.J., 2016. Vet Rec 178, 71.

Table 1. Risk factor model with the presence of ITN on the farm. (n=217).

Variable	OR (Wald lci-uci)	P value
Intercept	0.61 baseline odds (no UCD or chapped teats)	
UCD	2.80 (1.54-5.07)	<0.01
Chapped teats	6.07 (1.96-18.76)	<0.01

The effect of suckling position on piglet supplementary milk usage

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Application: Individual identification of piglet supplementary milk (SM) usage revealed that although piglets without a teat to suckle had high SM usage, this was insufficient to fully support their growth. Therefore, additional nutritional input is required. Introduction Piglets born alive/litter for the top 10 % of UK herds has increased from 12.7 – 15.3 in the last 10 years (AHDB, 2020). Provision of SM has been shown to increase piglets weaned in large litters (by up to 1.4 pigs/litter, Kobek-Kjeldager et al., 2020), but little is known about which individual piglets consume SM.

Materials and methods: Piglets were weighed at birth and weekly. SM was provided to all litters and PigTrack® (Asserva) equipment identified SM visits and duration from piglet's electronic ID (EID). Suckling position (anterior A, centre C, posterior P, not observed suckling N) was observed six times: two successful sucklings at day 4,14 and 24 of lactation. Only piglets whose suckling position did not vary between observations were included in the analysis (68 % of pigs observed). Piglet SM dry matter (DM) consumption was estimated daily based on the work of Icely et al. (2020), with a repeated measures ANOVA performed for intake from d14 to d24, using Genstat (18th edition). No creep feed was offered. Results Average daily gain (ADG) from birth-weaning and weaning weight reduced from anterior to posterior suckling position ($P < 0.001$; Table 1). Piglets not observed suckling were lightest at weaning, with the highest SM usage from d4 to weaning, but there was no difference in SM usage for suckled piglets ($P < 0.001$).

Table 1: Performance of piglets suckling different sections of the udder.

	A	C	P	N	s.e.m	P - value
n	141	160	113	8		
Birth weight (kg)	1.55[a]	1.45[b]	1.44[b]	1.23[b]	0.118	0.004
Wean weight (kg)	9.72[a]	8.87[b]	8.08[c]	5.15[d]	0.619	<0.001
ADG birth-wean (g/d)	292[a]	266[b]	238[c]	138[d]	20.8	<0.001
Average duration/d SM usage (s)[†]	166[a]	183[a]	210[a]	1135[b]	0.13	<0.001

[†]Log 10 transformation required, actual means presented. Suckling position anterior = A, centre = C, posterior = P, not observed = N. s.e.m = pooled standard error of the mean

Figure 1 shows the pre - weaning increase in estimated SM DM intake over time ($P < 0.001$) for piglets observed suckling (S) and not (N), but there was no suckling*time interaction ($P = 0.634$).

Conclusion: Supplementary milk was unable to fully compensate for a lack of sow milk where piglets were not observed suckling. Further work is needed to determine a pre – weaning strategy to enable unsuckled piglets to perform at similar levels to suckled littermates.

References: Agriculture and Horticulture Development Board, 2020. Available from: https://porktools.ahdb.org.uk/prices-stats/costings-herd-performance/indoor-breeding-herd/.
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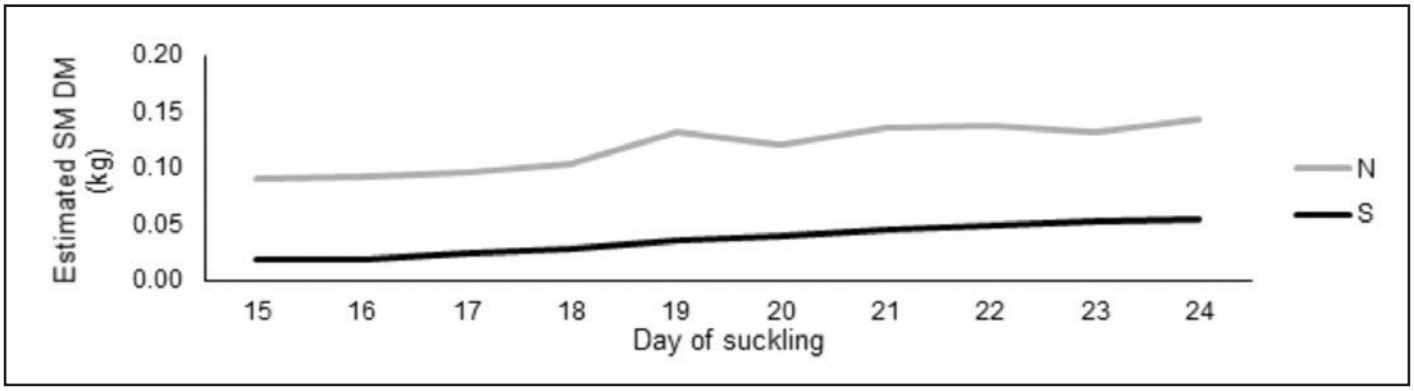
Kobek-Kjeldager, C., Moustsen, V.A., Theil, P.K., Pedersen, L.J., 2020. Animal 14 (4), pp 824 - 833.

Acknowledgements: Funding gratefully received from AHDB Pork, Primary Diets Ltd, JSR Genetics Ltd

Figure 1: Increase in estimated SM DM consumption over time of piglets observed suckling (S) or not (N)



Does a flock specific vaccine for footrot improve control of lameness in English sheep flocks?

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Application: An efficacious footrot vaccine would reduce the incidence of lameness due to footrot in sheep, which would improve welfare and productivity, reduce the labour involved in catching and treating lame sheep and decrease the number of antibiotic treatments used in the sheep sector.

Introduction: Footrot is a painful disease of sheep that causes inflammation and necrosis of the interdigital skin and degradation of the hoof horn. It is the most common cause of lameness in flocks in England and a serious welfare issue (Winter, et al., 2015). Footrot is caused by the bacterium Dichelobacter nodosus, which possesses fimbriae essential for virulence. Ten serogroups are known, designated A-I and M, classified by antigenic differences in the fimbrial subunit protein, FimA. The protective antibodies raised by sheep are not cross protective between serogroups. A commercial vaccine, Footvax®, contains serogroups A-I but has had a limited impact on footrot control. One reason for this may be 'antigenic competition' (Raadsma, et al., 1994). As the number of serogroups included in a footrot vaccine is increased, the amount of protective antibody produced towards each antigen decreases. Bivalent serogroup vaccines have been successful in the control or elimination of footrot in flocks in Australia (Dhungyel, et al., 2013).

Materials and methods: Three commercial sheep farms in the South West of England were enrolled to participate in a clinical trial. The two most prevalent serogroups in a cohort of 20-21 ewes in each flock were selected to include in a flock specific vaccine for that flock. The clinical trial commenced in August 2020. Between 180 and 200 ewes in each flock had every foot examined. Interdigital skin swabs were taken from all feet if footrot was observed. Ewes were stratified by breed, condition score and footrot score, then randomly allocated to one of three treatment groups in approximately equal numbers: Custom R-Pilus footrot vaccine, Footvax®, sterile saline. A second dose was administered four weeks later. The farmers and researcher were blinded to the treatments received and the ewes were not managed separately. Every week the ewes' locomotion was scored (Kaler, et al., 2009). In ewes with footrot the lesion was scored and all four feet were swabbed.

Conclusions: The clinical trial is due to finish at the end of April 2021. Once it has been completed the treatment administered to each sheep will be unblinded to allow analysis of the observational data. The observational data will be supported by quantitative and serogroup PCRs of interdigital skin swabs taken throughout the clinical trial.

Acknowledgments: The authors acknowledge funding from BBSRC and AHDB. This is a MIBTP studentship.

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Aetiopathogenesis and genomic architecture of resistance to claw horn disruption lesions in dairy cattle

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Application: This study aims to further the understanding of the development of claw horn disruption lesions (CHDL); this may lead to new prevention strategies, treatment options and the ability to select for animals genetically resistant to CHDL's.

Introduction: Lameness within the dairy industry is a pressing concern, with substantial numbers of cows adversely affected. The effects of lameness are wide ranging; impacting cow welfare (Whay et al., 1998), milk yield, and fertility and posing significant economic costs to the industry (Charfeddine and Pérez-Cabal, 2016). Over 90% of lameness cases originate in the foot with a large proportion being caused by non-infectious CHDL's. This descriptive term encompasses sole ulcers, white line disease and sole haemorrhage. Despite their importance, the aetiopathogenesis of CHDLs is still to be fully elucidated. This study aims to identify key factors related to foot anatomy and structure, fat mobilisation, metabolic stress and the animals' immune and hormone profiles during the periparturient and early lactation period that underlie/predispose to the development of CHDLs in dairy cows by using repeated measurements on a large number of Holstein cows and advanced statistical analysis.

Material and Methods: In total, 2,353 Holstein Friesian cows and heifers were enrolled in this study from four commercial dairy farms. These animals were enrolled approximately 30 to 60 days before parturition. These animals were then re-examined within 7 days of parturition, at 50-100 days post-parturition and at 170-200 days post-parturition.

At each time point the animals were mobility and body condition scored. The animals were then restrained in a foot trimming crush and thermography images were taken of both hind feet before all four feet were assessed for the presence of both infectious and non-infectious foot lesions, with lesions graded for severity. An image of the digital cushion on the lateral claw of the hind left foot was taken using B mode ultrasonography at 6MHz (Draminski 4 Vet Mini) using a linear transducer, with gel standoff and ultrasound gel used to obtain the image. These images were collected for measurement at a later date. Blood samples were also collected. Farm records relating to health, production and survival have also been obtained.

In total, 14,899 thermography images and 7,866 digital cushion images have been collected and analysed using FLIR and Image J software respectively. A further 7,015 serum samples are currently stored in preparation for analysis of the metabolic, inflammatory and hormonal status of the animal. This data will be analysed implementing mixed effect models using the R package. Moreover, all animals have genome wide genotypes generated to identify SNPs and genomic regions associated with CHDLs and those animals with extreme phenotypes and genotypes will be selected to undergo further functional genomic analyses.

Acknowledgements: The authors thank BBSRC and AHDB for their support.

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Survival of Streptococcus dysgalactiae on different bedding materials used in UK lambing

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Application: This project aims to determine Streptococcus dysgalactiae survival across different commonly used bedding materials, providing farmers with practical preventative solutions for infectious arthritis in neonatal lambs.

Introduction: Neonatal infectious arthritis is a debilitating condition caused by the bacteria Streptococcus dysgalactiae. Clinical symptoms (hot, swollen, painful joints) result in lameness and, with disease progression, recumbency. As the pathogen is exceedingly difficult to isolate, the route of transmission is currently unknown. It is hypothesised to occur via exposure of the neonatal lamb to environmental contamination (Rutherford et al., 2014), thus current preventative measures encompass enhanced lambing hygiene, including bedding/pen management (Hovers, 2014). Rutherford et al. (2014) found Streptococcus dysgalactiae could survive for up to 42 days on straw; the bacteria appear to survive well on dry straw and less favourably in damp conditions (Nicholas and Loria, 2014). Sawdust is considered bactericidal for Streptococcus dysgalactiae, perhaps making it a preferable bedding choice, however, no studies comparing survival across different bedding materials have yet been published (Hovers, 2014). This study aims to compare the survival of Streptococcus dysgalactiae on three different commonly used bedding materials, in damp and dry states.

Materials and Methods: Unused bedding (straw, sawdust, and soil) obtained from the University of Liverpool farm, was sterilised and added to sterile universal containers, either dry or sufficiently dampened with sterile water. 1ml of a 0.5 MacFarland suspension, of a clinical Streptococcus dysgalactiae isolate, was added to each bedding sample and stored aerobically across 8 time points: 0, 1, 2, 4, 7, 10, 14, and 21 days. Following this, maximum recovery diluent was added and samples were homogenised using a Stomacher (300rpm, 1min). The resulting suspension was serially diluted in saline, plated on 5% sheep's blood agar in triplicate, and incubated at 37oC for 24-hours under anaerobic conditions.

Results: Soil and damp soil displayed a 0.27 and 0.17 log increase in colony-forming units by day 2, before an overall reduction of 1.66 and 2.64 log by day 21, respectively. Dry sawdust did not support detectable bacterial survival at any time point past day 0. Damp sawdust demonstrated a 0.01 log reduction at day 4 and a 2.92 log reduction at day 14; Streptococcus dysgalactiae was undetectable at all other time points. Streptococcus dysgalactiae was able to survive on dry straw up to day 4, with a 0.03 log reduction in colony-forming units, before becoming undetectable. Damp straw results are pending.

Conclusions: There is a difference in survival and growth patterns of Streptococcus dysgalactiae between different bedding materials in dry and damp states. Dry sawdust was incapable of sustaining Streptococcus dysgalactiae survival, suggesting it may be a preferable bedding choice for farms suffering from Streptococcus dysgalactiae neonatal infectious arthritis. The importance of a dry, clean lambing environment is highlighted, further supporting current advice on bedding/pen management.

Acknowledgements: The author acknowledges funding from the University of Liverpool and AHDB Beef and Lamb.

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Investigating the relationship between the Nix Pro Colour Sensor and Minolta Chroma Meter CR-400 for effectively measuring lamb loin colour

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Application: Being able to quickly and easily identify lamb with an undesirable colour will allow the industry to better utilise meat for less wastage and a more consistent end product.
Introduction: Colour is widely regarded as an important factor for which consumers judge fresh meat quality (Alvarenga et al., 2019), as well as highlighting potential quality issues during processing (Holman et al., 2019) such as meat which is dark firm and dry or pale soft and exudative. The majority of colour research is carried out with expensive measuring devices such as the Minolta Chroma Meter CR-400. These types of instruments can be bulky and costly and may not always be the best suited method to use outside of research. The Nix Pro Colour Sensor is a smaller and comparatively cheaper device which could be used in practice to allow quick decisions to be made during processing. Whilst there is evidence that the Nix Pro Colour Sensor accurately measures meat colour (Holman et al., 2019), its effectiveness against the Minolta Chroma Meter has not been investigated in detail.

Materials and methods: Lamb loin (Longissimus dorsi) samples were vacuum packed and frozen after a period of 10 days maturation post-slaughter. Prior to testing, packaged samples were defrosted at 4oC for 72 hours. Following a bloom time of 3 minutes (under fluorescent lighting), 327 loin samples were measured, by both the Nix Pro Colour Sensor and the Konica Minolta Chroma Meter CR-400. 3 readings were taken from each sample which gave a total of 981 individual readings per instrument. Pearson's Correlation was performed using the RStudio software to assess the presence and strength of relationship between the two instruments followed by regression analysis.

Results: Preliminary analysis (table 1) shows that there is a positive correlation between Minolta Chroma Meter and Nix Pro (with Nix set at illuminant D50) when considering lightness (L*), red/green (a*) and blue/yellow (b*) ($p<0.001$).
Table 1: Correlation and regression results for Minolta Chroma Meter and Nix Pro (with Nix set to illuminant D50). *** = $p<0.001$

Conclusion: Whilst the results show that there is a relationship between the two methods, this is somewhat expected as the instruments measure colour with the same parameters (Giavarina, 2015). To further understand the differences between the two instruments and whether the Nix Pro could be used in place of the Minolta Chroma Meter, the results will be further analysed using the Bland-Altman coefficients theory. Bland and Altman (1986) argued the incorrect use of correlation coefficients when comparing a new measurement technique with an established gold standard.

Acknowledgements: The author acknowledges funding from AHDB.

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	Pearson correlation coefficient	Regression intercept	Regression slope	R2	Sig.
L*	0.745348	9.98844	0.79453	0.5555	***
a*	0.7845185	-3.33388	0.99590	0.6155	***
b*	0.6206774	0.41885	1.08670	0.3852	***

Prediction of growth rate in grower-finisher pigs using recurrent neural networks

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Application: Livestock farming may benefit from precision agriculture tools to provide estimates of growth and feed efficiency and early-warning of potential disease outbreaks. Introduction: Accurate prediction of pig growth is an important goal for pork production efficiency due to the potential benefit to farm management in monitoring growth according to target and planning sale of finished animals. Machine learning approaches have already been used on pig data in a variety of contexts, such as monitoring water consumption and environmental parameters to predict outbreaks of tail-biting and diarrhoea (Domun et al., 2019). Our aim was to develop models to predict the length of time taken for growing pigs to reach target finished weight based on data sources that can be captured in commercial conditions.

Material and methods: Data for 424 pigs were obtained from a commercial UK farm between March 2019 and December 2020. The data consisted of liveweight and food consumption data recorded by individual feeding stations (Nedap, Netherlands) in groups of grower-finisher pigs housed in a fully-slatted building, and environmental temperature data recorded by the building control system (Farmex, UK). Liveweight data were pre-processed using an in-house outlier removal algorithm based on linear regression. Over each day and for each pig, weight data points were averaged and food consumption quantities were summed. Prediction models consisted of both fully connected neural layers and bidirectional recurrent LSTM (long short-term memory) neural layers. The models were trained to predict the number of days that it would take each pig to reach a target liveweight of 85 kg at each time step (day) when using liveweight, food consumption and environmental temperature data as input features. Statistical comparisons were carried out between models trained with either complete daily temperature sequences (96 samples, each measured 15 minutes apart), average daily temperature only, or without any temperature data.

Results: Figure 1 shows that, with lower root mean square error (RMSE) values, the model which utilised the full temperature sequence outperformed the other models ($P < 0.05$). Figure 2 shows predicted versus true values for the best performing model (correlation coefficient of 0.968, $P < 0.05$). The mean line deviates from the diagonal (ideal predictions) past 47 days due to a lack of data as few pigs took this long to reach 85kg.

Conclusions: The models developed in this study were very effective at predicting the growth of grower-finisher pigs over a 40 to 85 kg liveweight range, although further work is required to understand how the models are utilising the environmental temperature data.

Acknowledgements: Funding from AHDB (Agriculture and Horticulture Development Board) for CT is acknowledged.
Reference: Domun, Y., Pedersen, L. J., White, D., Adeyemi, O., Norton, T., 2019. Computers and Electronics in Agriculture, 104878.

Figure 1: Cross-validation RMSE scores of models trained to estimate length of time to reach 85 kg liveweight using different temperature features.

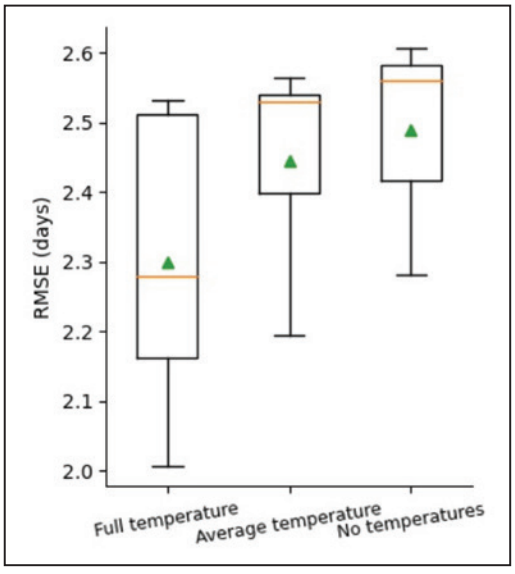
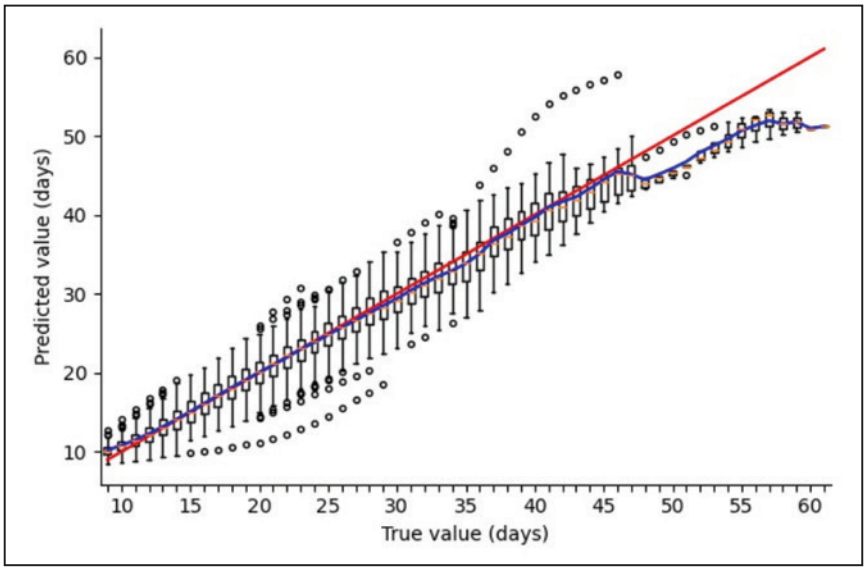


Figure 2: True vs predicted values for length of time to reach 85 kg liveweight when using full temperature sequences (red line represents the ideal predictions, blue line represents per-day mean values).



A randomised control trial to evaluate the effect of preventive hoof trimming before first calving on subsequent lameness in first lactation dairy heifers

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Application: Lameness is the most significant welfare concern in dairy cattle and a substantial challenge to the profitability, sustainability and reputation of the industry. This research is focused on preventive hoof trimming to identify if, how and when this should be undertaken in order to reduce future risk of lameness.

Introduction: Preventive hoof trimming has a role to play in the prevention of lameness in dairy cattle (Manske et al., 2002) and is a common part of lameness management on UK dairy farms. Despite this, there is very little peer-reviewed literature in this subject area. The aims of this study are to determine if preventively trimming heifers before first calving can reduce lameness in early lactation and whether an adaptation to Step 3 of the five-step functional trimming method to incorporate a deeper, wider sole model to alleviate sole weight-bearing in International hoofmap zone 4 is beneficial.

Materials and Methods: Approximately 1,000 pregnant heifers will be enrolled from five farms between September and December 2021. Heifers will be enrolled 50-70 days prior to their predicted calving date and allocated to one of three groups using stratified randomisation:

- Negative Control: Not trimmed
- Treatment 1: Five step functional trim
- Treatment 2: Five step functional trim with a deep, wide model being incorporated for Step 3

Heifers will be enrolled at two-week intervals. Any heifer with a known history of lameness will be excluded prior to enrolment and any heifer that is lame or requires a therapeutic trim at the point of enrolment will also be excluded. All hoof trimming will be undertaken by trained and qualified hoof trimmers, supervised by SP. The size of the model on the hind lateral claws will be standardised for each group using bespoke gauges.

Following enrolment heifers will be scored for mobility on a fortnightly basis. At 60-90 days in milk (DIM) heifers will be re-presented for examination to record lesions present. Statistical analysis will be used to test the two following null hypotheses:

1. Preventive trimming in-calf heifers approximately 60 days prior to first calving does not significantly reduce risk of lameness and the prevalence of lesions detected by 90 DIM.
2. In-calf heifers trimmed approximately 60 days prior to first calving with a hoof trimming method incorporating a wide, deep model does not significantly reduce the risk of lameness and prevalence of lesions detected by 90 DIM compared to incorporating a small, narrow model.

Results/Conclusions: Following completion of the study, the results and conclusions will be expected to contribute to the evidence base surrounding preventive hoof trimming and help create best practice guidelines for dairy farmers.

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Author Index

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