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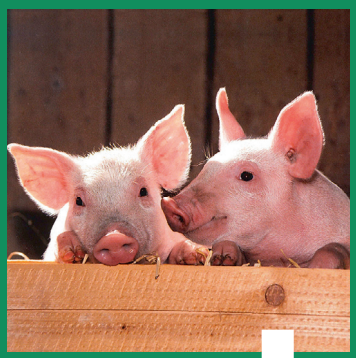

animal science proceedings

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The Proceedings of the British Society of Animal Science
The Proceedings of the British Society of Animal Science constitutes abstracts of papers presented at the Society's Annual Conference, BSAS 79th Annual Conference 2023 held at the International Conference Centre, Birmingham Centre and virtually on 28th - 30th April 2023

All the research reported in this issue complied with the relevant country regulations on ethics and animal welfare.

bsas
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Welcome

The British Society of Animal Science (BSAS) aims to provide an opportunity for those with an interest in animals and animal science to exchange views, ideas and information. It is an energetic and active society with members from countries throughout the world. Today, as ever, the Society is the natural connecting point for all of those with an interest in animal science and related sectors. Its membership is drawn from research, education, advisory work, commerce and practical animal keeping.

BSAS organises major scientific and specialist conferences on key issues facing the science related to animals. The 2023 annual conference addresses the topic of 'Animal Science: delivering for all our needs'.

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Proceedings of the British Society of Animal Science Annual Conference 2023

001 (Invited Speaker)

Turbulent times in the global food industry: The new normal for meat & dairy?

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Both literally and figuratively, the global food industry and its 8 billion customers have been buffeted from pillar to post this past 3 years and more. Worrisomely, the human Covid pandemic is not alone and there's a disconcerting global growth in some livestock diseases. War in Ukraine, with no proximate resolution, will continue to threaten economic, financial and mental stability and will create havoc with household budgets, and returns to agricultural and food industry businesses throughout this year.
Pre-pandemic, escalating consumer concerns about the impact of livestock production on the health of our planet were front and centre. Now, more immediate global troubles muddy our "worry pools". Glance at the food retail shelves and it's blindingly obvious that there are meat cuts and dairy products for "The Haves" and The Have Nots" as prices have escalated, albeit too late in the day for some producers and, concomitantly, household incomes have polarised. The social issues that occupied our minds about the impact of meat and dairy production have been constrained and affected our purchasing behaviour – higher welfare, organic food product sales have struggled as shoppers seek to cope with food, energy and interest rate inflation.
As our world and lives claw themselves back to what is more like normal or, more likely, a "New Normal", consumer concerns about the impact of climate change on our planet and their lives will be starkly heightened as the evidence of, *inter alia*, rising temperature and sea levels become frighteningly manifest. WWF's axiom "Food: the Power is on Your Plate" will be widely embraced by consumers around the world but, particularly, by those in higher income countries where diets have a high component of meat and dairy products. Is this an existential threat to the global livestock industry? NO! But, it is a propitious reminder that the journey to carbon neutrality in livestock production and meat and dairy processing must be accelerated.
By 2040, the nature of livestock production in the UK, Europe and most other major meat and dairy producing countries will be transformed by improved management, science, and technology. Seemingly unsurmountable hurdles associated with their climate impact will be significantly overcome, but not without issues for consumers concerned about animal welfare and new technologies perceived to be "unnatural". This has always been the case for many decades as agricultural productivity has been driven by emerging pure and applied science and is a paramount reminder of the need to explain to consumers of the benefits of new science to consumers themselves, to the planet and to the animals we farm.

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002 (Invited Speaker)

#CowsInTrees – The role of silvopasture in addressing animal health and welfare outcomes and farm sustainability goals

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This presentation shares lessons learned from the practical application of silvopasture in an upland context in North East Scotland. Integrating trees and cattle has led to interesting outcomes, and when combined with adaptive multi paddock grazing and a comprehensive monitoring programme, the use of anthelmintic treatments has remained at zero for 4 years.

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003 (Invited Speaker)

Sustainable control of roundworm infections in livestock

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Parasitic gastroenteritis (PGE) caused by roundworm infection is one of the most important production-limiting diseases in grazing livestock, costing UK sheep producers £42.2 million per year in treatment and lost production. Infection can cause production losses such as reduction in live weight gain and reductions in meat/wool quality/quantity. Worms have developed resistance to many of the wormer (or anthelmintic) classes that are available, however, this is not uniform across all farms. It is critical to move away from routine (or blanket) worming, where all animals in a group are treated at the same time, because this selects strongly for wormer resistance. Instead, a move towards control based on strategies that aim to reduce the worm burden through management and identifying selecting only those animals that need to be treated is required. This will allow us to reduce our reliance on wormers, improve the accuracy and results gained from any treatments we do give and reduce environmental impacts. Here, we will look at 2 main areas, the use of optimising wormer treatment with the help of technology and the potential benefits of improved sward mixes and grazing management.
Worming treatments can be optimised by treating just individual animals; this is known as Targeted Selective Treatment (TST), as we are aiming to target wormer treatment to selected animals within a group. The TST strategy employed here has been the use of a specific algorithm to predict a target weight gain for weaned lambs, over a 2–4 week period. Lambs are weighed, and any underperforming (i.e. not reaching the weight target) are wormed, those that reach the target are not wormed as they are performing well. Integrating the algorithm on a cloud-based platform (AgriIgnite) and with EID-linked electronic weigh crates makes the implementation of this approach simple and quick to use on-farm. The use of this TST strategy on-farm has resulted in reductions of 40–50% in wormer use and the slowing of anthelmintic resistance, whilst maintaining lamb productivity. This approach helps to reduce the time required for worming on-farm and, therefore, reduces costs compared to 'blanket worming' (Kenyon et al, 2013, Int. J. Para: Drugs & Drug Res.3: 77-83; Morgan-Davies et al, 2018, Livestock Sci, 208: 67–76).
There is much interest now in the use of 'regenerative' grazing strategies incorporating more biodiverse swards and rotational/mob grazing and how these can help animals to remain productive. As yet, there is limited empirical evidence to show the pros and cons of the introduction of these approaches on lamb production, roundworm infection and wormer use. New studies undertaken at Moredun will compare the impact of biodiverse swards and rotational grazing approaches with traditional ryegrass/set-stocking. We also aim to combine TST strategies with these strategies to try to deliver livestock production that is sustainable, using minimal wormer treatments, leading to improved biodiversity.

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004 (Invited Speaker)

The resilience of optimisation

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After many years of capturing farm data and through this time the farming and grazing model has changed from set stocking, to rotational grazing, to longer rotation's encompassing taller pastures. The KPI's that drive the ethos of this livestock business have changed. No longer are we focused on maximizing the potential of an EBV, but rather allowing the pressure of the grazing system to select functional and productive genetics.

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005 (Invited Speaker)

Delving into dung (Dung beetles for farmers)

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Just how important are dung beetles in our livestock systems and what are they doing beyond removing dung? We generally don't think of the insect communities based around the dung piles in our fields and these include our native dung beetles. But what if we lose these beetles? What effect would it have on our pastures, soil and farm biodiversity? By gaining an understanding of dung beetles we can implement small changes in our management decisions that could have much wider benefits.

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006 (Invited Speaker)

Livestock health, disease and research – From farm to fork

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From farm to fork, improving animal health and welfare of our livestock is vital for our industry. Better health means better welfare, better productivity and better environmental outcomes for our farms. But our research has much wider ramifications through the food industry be that on trade, food security or human health. Examples of good research that have made significant impact through to poor research with disastrous outcomes will be discussed. And it is not just the research itself - the interpretation of research and its application on farm or in the food chain can yield phenomenal results - but both good and bad. AHDB is positioned at the interface of research and farming yet this interface can be neglected by researchers and huge opportunities missed. The competitive nature of research funding means we have to strive to reap maximum benefit from our investments. Understanding how to make research impactful as well as understanding the needs of the livestock sector will determine future funding as well as the future of the industry. It means the research outcomes should not only be clear, but also are practical and understood by those who will implement the changes. Having the mechanisms for research dissemination and evaluation complete the process and feed back into the likely future needs of the livestock sector. Aligning research with the industry needs will make a more resilient food system and ensure that we have world leading animal health and welfare.

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007

Improving monitoring of passive transfer in dairy heifer calves by using empirically derived thresholds to predict failure of passive transfer and disease risk

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Application
Passive transfer of immunity through ingestion of colostrum is commonly monitored on farms. It is known to be a critical indicator of calf health. Improving how these measures are used can improve on farm calf health and welfare, and reduce on-farm costs.

Introduction
Neonatal calves are dependent on passive transfer of immunity via ingesting colostrum from the dam, consequently, monitoring of passive transfer is important in both clinical and research contexts (Godden, 2008). The level of maternal IgG in calf serum in the first week of life is assessed to determine successful IgG transfer – traditionally, $ZnSO_4$ turbidimetric assays or radial immune diffusion (the gold standard) have been used to assess serum IgG – in the last 10 years there has been a significant research interest in using serum total protein as

a cheaper on farm proxy (e.g. Chigerwe et al., 2015). Generally, calves with <10 g/l IgG or 50 g/l total protein are defined as having failure of passive transfer (Godden, 2008), but the clinical relevance of these thresholds is not empirically proven.

Materials and methods
Three study cohorts were combined to provide a total of 726 dairy heifer calves from 15 farms in SE England. All calves had serum total protein and IgG assessed in the first week of life and were then monitored with weekly clinical examination until 9 weeks old. Receiver operated curves and generalised linear mixed effects models were completed in R.

Results
Failure of passive transfer (<10 g/l IgG) was observed in 120 (16.5%) calves. Serum total protein was well correlated with IgG (r^2 0.73, p < 0.001) and receiver operated curves used to determine the best cut off to use for total protein. For a cut off of 10 g/l, 48 g/l total protein correctly classified 93.3% or calves, for 15 g/l IgG 91.7% were correctly classified at 52 g/l total protein, and for 20 g/l the best cut-off was 56 mg/ml with 91.9% of calves correctly classified. Contagious disease was frequently observed in the cohort – 47.5% (95% confidence interval - 43.8–51.2) of calves had diarrhoea and 39.0% (95% confidence interval - 36.0–43.2) had respiratory disease. There was no correlation between diarrhoea risk and passive transfer status. Generalised linear mixed effects model predicted an odds ratio of 0.97 (95% confidence interval 0.98–0.99, p = 0.002) for each unit increase of IgG. Similarly, each unit increase of total protein decreased the odds of respiratory disease by 0.98 (0.9–0.99, p = 0.04). The relationship was linear with calves across the range of observed passive transfers experiencing disease. Growth rate was correlated with both serum total protein (estimate 0.0025, p = 0.003) and IgG (estimate 0.0032, p < 0.001).

Conclusions
These results suggest that higher levels of passive transfer are needed to reduce disease risk than was previously assumed - the empiracally derived thresholds using receiver operated curves suggested a cut off of 20.9 mg/ml would lead to the fewest number of classification errors. But it is important to note that that good passive transfer is not adequate to prevent this disease with most cases occurring in calves with good levels of IgG. Consequently, these results suggest that considering the linear range of IgG or serum total protein may be more informative than the cut off approach typically used on farm currently.

Acknowledgments
The main cohort of 500 heifers was funded by BBSRC and supervised by Dr Clare Wathes. Additional work was completed after my PhD and received no external funding.

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008

Bovine Ischaemic Teat Necrosis in dairy cattle: What we know so far

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Application
This multidisciplinary study reports farmer-reported experiences, identifies potential farm-level risk factors, estimates the economic impact of ischaemic teat necrosis on British dairy farms and investigates the potential pathogenesis to inform future control strategies.

Introduction
Bovine ischaemic teat necrosis (ITN) is an emerging disease affecting dairy cow teats with many affected animals being culled due to the disease. Little is known around the epidemiological, economic, pathological and aetiological data.

Materials and methods
A postal questionnaire was sent to a random sample of 1855 British dairy farmers. Descriptive statistics were employed to understand the main at-risk animals and the potential outcomes of the disease. The economic impact was estimated based on the different outcomes. Univariable and multivariable logistic regression models were used to explore associations between the presence of ITN on farm and various risk factors.

Photographs from 47 cows with 73 ITN lesions from 28 farms were reviewed for developing clinical grading system. Samples for histological examination (n = 18) where obtain from veterinary surgeons surgically removing teats (on clinical grounds) or cull cows from abattoirs/fallen stock centres. Gram stain, Periodic Acid-Schiff (PAS), Warthin starry (WS) and immunohistochemistry (IHC) for digital dermatitis treponemes were utilised to investigate potential aetiologies.

Results
A response rate of 12.3% was obtained with 51% (95% confidence interval (CI):44.4–57.8%) of farmers reported having ITN between 1985 and 2018. Rising numbers of farms reporting the first case indicated ITN as an emerging disease. At the animal level, 47.3% (CI:38.7-–5.9%) of cases were first lactation cows with 78.9% (CI:75.2–82.6%) within the first 90 days in milk. Only 20.8% (CI:15.9–26.4%) of cases were reported to recover, whereas 22.8% (CI:17.8–28.5%) required culling and 56.4% (CI:50.0–62.6%) were complicated by teat loss and/or mastitis. Subsequently, the cost of ITN, was estimated to be £1121/farm/year with individual estimates at £720, £860 and £2133 for recovered, complicated and culled cases, respectively. The presence of udder cleft dermatitis (UCD) (odds ratio:2.80; CI:1.54-5.07; p-value < 0.01) and chapped teats (odds ratio:6.07; CI:1.96–18.76; p-value < 0.01) in the milking herd were associated with cases ITN.
A three-point clinical grading system was applied: Type 1- area of necrosis at the teat-udder junction; Type 2- proliferative teat lesion with crusting; and type 3- absence or sloughing of teat. Histologically all types had suppurative inflammation, type 1 lesions had epidermal and dermal necrosis and type 3 had eosinophilic infiltrates. Gram stain and WS demonstrated mixed population of bacteria, no other agents were detected on PAS or IHC.

Conclusions
This national questionnaire highlights the association of UCD and chapped teats with ITN at farm-level. Three clinical grades with some histological differences allow for more rapid diagnosis. These findings highlight several areas for further investigations, interventions, currently an aetiological agent has not been discovered.

Acknowledgments
BBSRC and AHDB for funding this study; farmers for returning questionnaire; allowing use of data and allowing access to farms and animals; ADHB for access to database; veterinary surgeons for submitting samples.

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009

A cross sectional study on the point prevalence and risk factor for Fasciola spp. in slaughtered ruminant at Kirkuk, North Eastern Iraq Abattoir

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Application
It aimed at showing the impact of F. hepatica on ruminants represented by causing major diseases to cattle, which in turn produces considerable losses in economy.

Introduction
This study aimed at investigating Fascioliasis prevalence in North Eastern Iraq Abattoir. Liver fluke is the most widely prevalent zoonotic diseases, and it is a serious economic disease of sheep and cattle with a worldwide distribution. However, affecting no less than 250 million sheep and 300 million cattle throughout the world. Likewise, it is a common parasitic disease in ruminants and may also affect humans (Calvani and Šlapeta, 2021). Fasciola spp. has two main types, they are: F. gigantica and F. hepatica. Differences of these types can be through morphological features like body length and shape (Fox et al., 2018). Fascioliasis transmission is dependent on the presence of its snail intermediate host; consequently, the distribution of the liver fluke is limited to geographic areas where the appropriate snail species is present (Calvani and Šlapeta, 2021). In non-prevalent areas, diagnosis of liver fluke can be difficult and usually is delayed because the disease is not often encountered and the symptoms may be confused with other biliary or hepatic disorders. Diagnosis of F. hepatica infection method is complex and unpredictable but has usually relied on detecting the presence of eggs in fecal samples (Fox et al., 2018).

Materials and methods
The study was conducted from October 2021 to May 2022 on different animals (cattle, sheep, buffaloes and goat) at North Eastern Iraq Abattoir, situated at the south east part of Kirkuk. Meat of the animals under study was mostly inspected by professionals in the field of animal health. Veterinarians were called when having difficulties. Concerning the observation system, inspectors of veterinary meat examined each slaughtered animal during their routine responsibilities. Reasons for disapproval of tissues including fascioliasis were noted daily on prepared data sheets. The F. hepatica was distinguished by faecal samples were taken and stored without fixatives at 4 oC until they were analysed by Rapid assessment of faecal egg count. A software called Sigma Plot (version 12) was used to analyse the data.

Results
In this slaughterhouse, there were 18742 slaughtered sheep, 8675 cattle, 2564 goats, and then 232 buffaloes. The total number of affected animals with fascioliasis were recorded highest ($P < 0.05$) in January: 82 animals, followed by February: 71 animals, November: 47 animals, nevertheless, the lowest record was in May: 7 animals only. Liver fluke at January had a 6.8 times increased risk of lesions (Chi square $P < 0.05$). The presence lesion elsewhere on the liver decreased the risk of having an ocular lesion to one eighth after March (Chi square $P < 0.05$).

Conclusions
This inspection has helped illustrating the utility of records of meat inspection in observing situations of disease and establishing potential extended term trends. The study found that winter (the highest humidity recorded) is crucial for animals as a results of its highest rates of infection, followed by spring and autumn seasons. A moist environment is needed to keep the snail's body from drying out and to enable it to get more oxygen from the air that enters its shell cavity through the breathing hole.

Acknowledgments
The authors thankful for the staff of slaughterhouse in relation to gathering the required data for the current investigation, their effort is highly appreciated. This study was approved and funded by the Audit Committee of the Kirkuk University Trust.

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010

Farm-level drivers of antimicrobial use and resistance in livestock: An evidence synthesis

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Application
A sector-wide synthesis of literature was used to identify predictors of antimicrobial use and resistance in European livestock, with the design of visualisations for each livestock production system highlighting critical control points and research gaps in the field.

Introduction
Antimicrobial resistance is a major threat to health globally and a key One Health issue impacting humans, animals, and the environment. Livestock have been highlighted as a target for moderation of antimicrobial use (AMU), which is considered an important driver of resistance (AMR). Some studies have assessed AMU and AMR in individual production systems, but there is a significant research gap in identifying the key drivers of AMU and AMR across farming systems. The objective of this study was to address this research gap by synthesising the evidence across the European livestock sector.

Materials and methods
Commissioned by the UK Veterinary Medicines Directorate, this study reviewed existing English-language literature describing original peer-reviewed research to identify critical control points in farm animal husbandry and management in the UK and Europe. AMU and AMR predictors were identified for pigs, layer and broiler hens, beef and dairy cattle, sheep, turkeys, and farmed salmon. These were synthesised into a series of conceptual models of the farm-level predictors of AMU and AMR throughout the production cycle for each livestock type. For species for which peer-reviewed literature was scarce, grey literature was used to identify additional possible risk factors for further investigation.

Results
The review revealed significantly unequal representation of livestock types among analyses in peer-reviewed literature (X^2 test, $p < 0.001$). Sheep, laying chickens, broiler turkeys and salmon were underrepresented, with under 5% of total analyses addressing AMU/AMR risk factors for each of these categories. Across systems, important tools to mitigate AMU/AMR included biosecurity and herd health plans; organic production typically showed significantly lower AMU but even in antibiotic-free systems, varying levels of AMR were identified in livestock microflora. The impacts of vaccination on AMU and AMR in livestock were unclear and require further research. The AMU/AMR impacts of intensive versus extensive systems varied between species. For example, free-range pigs showed lower AMR than those raised in indoor systems, while this effect was not demonstrated in broiler chickens and some studies showed the opposite pattern.

Conclusions
The quality and quantity of available evidence differed dramatically between livestock types and even in the more extensively researched species, important knowledge gaps were apparent. The differing effects of production systems between species highlight the importance of researching these further rather than extrapolating between livestock types. Further investigation of the impacts of vaccination on AMU and AMR is needed across species. This study synthesises a broad body of research, filling a conspicuous gap in the existing AMR literature.

Acknowledgments
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011 (Invited Speaker)

Developing models for predicting the total feed intake of growing cattle

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Application
Accurate prediction of feed intake is essential for rationing cattle to achieve targeted levels of performance.

Introduction
Dry matter intake (DMI) is the most important variable influencing ruminant's production and accurate predictions of this is a pre-requisite of effective ration formulation. However, measuring intake, especially on-farm conditions is not always an easy task and alternatives have been proposed. Feeding systems around the globe have developed empirical models for predicting feed intake in growing animals by integrating both animal and diet-related factors that have been identified as key drivers modulating intake responses in their local conditions. There is evidence indicating that some of the international models used do not accurately predict feed intake whilst evaluated under UK systems (Cabezas Garcia et al., 2021). The objective of this study was to develop new models for predicting DMI.

Material and methods
Data used were collated from nine production studies undertaken at AFBI involving 1137 cattle. Animals had a mean age of 12.1 months (sd 3.11); initial live weight 294 kg (sd 80.4), final live weight 514 kg (sd 107.8), DMI 9.3 kg (sd 1.90) and live weight gain 1.44 kg/day (sd 0.255). Feed intake data was based on group intakes (mainly based on the average of 4 animals per pen) which were recorded daily. Live weight was based on fortnightly weights. Cattle were offered diets containing a mixture of forage and concentrates. Two statistical approaches combining animal and diet related factors were used to build the mixed models including (a) non-linear (power function) and (b) linear (combination of prediction factors).

Results
Non-linear and linear equations were developed for predicting DMI as follows:

$$\text{Total DMI (kg/d)} = \begin{cases} 0.356 * LW^{0.547} \\ 0.762 + 0.243 * LW^{0.60} \\ 8.607 + 0.224 * LW^{0.60} - 0.0190 \times NDFconc \\ 8.881 + 0.221 * LW^{0.60} - 0.0187 \times NDFconc - 2.895 \times NH_3\text{-N} \end{cases}$$

$$\text{Total DMI (g/kg}^{0.75}) = SIP * (1 - (0.7316\ ConcProp + 0.2433\ ConcProp^2)) + (77.37\ ConcProp + 36.24\ ConcProp^2)$$

$$\text{Silage DMI (g/kg}^{0.75}) = SIP * (1 - 0.0084\ CDMI)$$

where CDMI = concentrate DMI (g/kg$^{0.75}$), ConcProp = dietary concentrate proportion (kg/kg DM), LW = live weight (kg), NDFconc = dietary NDF concentration (g/kg DM), NH_3-N = ammonia nitrogen in silage (g/kg N), SIP = NIRS grass silage intake potential (g/kg$^{0.75}$)

Conclusions
New models for predicting total dry matter intake has been developed for growing cattle. Models with additional information on the diet provide better estimates of feed intake than equations relying only on the animal live weight.

Acknowledgements
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Reference

Cabezas Garcia, E., Lowe, D., Lively, F.O., 2021. Animal - Sci. Proc. 12 (1), 24.

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012 (Invited Speaker)

Estimates of the maintenance energy requirement of beef cattle using respiration chamber data

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Application
Accurate prediction of maintenance energy requirement is essential for rationing beef cattle to improve production efficiency and reduce environmental footprint.

Introduction
There is evidence that AFRC (1993) underpredicts maintenance energy requirement for modern beef cattle (Jiao et al., 2015). The objective of this study was to determine maintenance energy requirement for beef cattle using more recent respiration chamber data.

Material and methods
Data used were collated from respiration chamber studies undertaken at AFBI (n = 249) and the University of Reading (n = 48) between 1993 and 2015. The dataset comprises data from 176 growing dairy and beef steers, 88 growing Holstein heifers and 34 dry suckler cows. Steers and heifers were at age of 6 to 30 months when housed in chambers. Cattle were offered diets containing either forage only (n = 81) or a mixture of forage and concentrates (n = 211) at production feeding levels. Energy intake and outputs were measured using indirect open-circuit respiration calorimeter chambers and digestion trials. Linear and multiple linear regression techniques were used to evaluate relationships between retained energy (RE) and metabolizable energy (ME) intake (MEI), with experiment as a random effect.

Results
The mean metabolic live weight (MLW) was 101 (s.d., 20.8) $kg^{0.75}$ and ranged from 41 to 154 $kg^{0.75}$. The corresponding values for MEI were 0.86, 0.185, 0.44 and 1.44 $MJ/kg^{0.75}$ and RE are 0.13, 0.145, −0.24 and 0.64 $MJ/kg^{0.75}$. These data were used to develop linear regression ($MJ/kg^{0.75}$): RE = 0.604 MEI - 0.423 (R^2 = 0.89) and multiple linear regression (MJ/d or $kg^{0.75}$): MEI = 0.558 MBW + 1.210 RE (R^2 = 0.89). The NE (NE_m) and ME (ME_m) requirements for maintenance derived from these 2 equations are respectively 0.423 and 0.558 $MJ/kg^{0.75}$ and 24% and 19% higher than those recommended by AFRC (1993). The linear regression of RE against MEI was also used to evaluate if there was any significant difference in NE_m between genders (heifer vs Steer vs suckler), between live weight groups (<350 vs 350-500 vs >500 kg), between forage types (grass silage vs non-grass silage) and between forage proportion (forage only vs mixed diets). The results demonstrated that with a common slope, there was no significant difference in constants (NE_m) within any group.

Conclusion
The present result indicates that use of AFRC (1993) to ration current heifer or beef cattle can underestimate their maintenance energy requirement. Cattle gender, live weight group, and forage type and proportion had no significant effect on NE_m determined by regression of RE on MEI.

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013 (Invited Speaker)

Modelling the composition of liveweight gain in beef cattle

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Application
Revised model for the composition of liveweight gain, and so energy and protein requirements for growth, in beef cattle.

Introduction
UK models of the composition of liveweight gain are based on slaughter data presented in ARC (1980); many of these studies were reported in the 1970s and some date back to the 1920s. The mature size and body composition of beef cattle has changed over the intervening period, partly through breed substitution and partly through selection for growth rates. This work sought to review these changes and propose changes to feed rationing programmes.

Review
The most comprehensive recent data set on the composition of beef cattle comes from INRA, with new models for 14 categories of growing or finishing beef cattle presented in INRA (2018). For each of these categories, we calculated the energy and protein content of liveweight gain, using both ARC (1980) and INRA (2018) models. On average across the 14 categories INRA (2018) values were 76.1% (s.d. = 15.62) and 105.2% (s.d. = 14.56) of ARC (1980) values for energy (MJ/kg) and protein (g/kg) respectively. Several of the INRA categories are not common in the UK (e.g. continental bulls) and INRA (2018) values were closer (93.9%; s.d. = 15.71) for the five most relevant categories. Our other source of information is Estimated Breeding Values for carcass fat content of UK cattle. These data are based on carcass classification at the abattoir and so representative of changes in the UK beef herd. Analysis was conducted separately for the most abundant beef breeds. These data are most complete between 2000 and 2019, so we looked at changes between 2000–2002 and 2017–2019. Converting to a carcass fat (g/kg) estimate using the relationship established by Conrad et al. (2010) and expressing over 40 years (i.e. extrapolating to the interval since ARC, 1980) shows reductions in carcass fat for British breeds (Aberdeen Angus (−7.1); Hereford (−6.1); Beef Shorthorn (−10.4)); little change for some breeds (Limousin (−3.6); Simmental (0.09); Stabiliser(−2.1)); and increases for large continental breeds (Charolais (+9.6); British Blue (+10.5)).

Conclusion
Differences between breeds in estimated fat (energy) and hence protein content are less than when the original classification of early, medium and late maturing breeds was established. The adjustment factors for predictions of the energy and protein content of liveweight gain (+15% and −10% respectively for early maturing breeds; −15% and +10% respectively for late maturing breeds) should be reduced by half. There may be scope to include estimated breeding values for carcass traits in refining beef rationing models.

Acknowledgment
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014 (Invited Speaker)

Validation of updated beef energy rationing models using AFBI experiment data

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Application
Accurately rationing beef cattle is essential for achievement of sustainable beef production.

Introduction
The FIBNUT project funded by CIEL has produced updated energy rationing models of AFRC (1993) for the current beef cattle. The objective of this study was to validate the FIBNUT proposal using AFBI beef experiment data.

Material and methods
The FIBNUT project proposes to update beef energy rationing models of AFRC (1993) in the following 3 areas: (1) using a fixed value of 0.423 MJ/kg$^{0.75}$ for net energy requirement for maintenance and a reduced activity allowance to predict ME requirement for maintenance; (2) using revised C2 factors of AFRC (1993) to correct the effect of sex and maturity on the estimate of NE and then ME requirements for liveweight gain; (3) using a reduction factor of 1% to convert dietary ME concentrations from maintenance levels to production levels. The FINUT proposal was then validated using data collected in 8 long term studies of AFBI undertaken from 2004 to 2018, with a total of 146 cattle (31 steers and 115 bulls). Animals were at various ages from 4.1 to 25.7 months at the beginning of experiments and offered grass silage-based diets from 10 to 34 weeks. Feed intakes were recorded daily and used to calculate daily ME intake (MEI) using estimated ME concentrations of silages (from the NIRS scan) and concentrates (using tabulated values). Liveweights were recorded weekly and used to estimate liveweight gain.

Results
The mean liveweight and liveweight gain are 418 (from 137 to 662) kg and 1.30 (from 0.58 to 1.90) kg/d, respectively. The validation was undertaken using actual MEI against predicted MEI. The mean actual MEI is 108 (s.d., 15.6) MJ/d, and the corresponding MEIs (MJ/d) predicted by the FIBNUT proposal are, respectively, 111 and 17.8, AFRC (1993) 96 and 15.5, NRC (2016) 113 and 20.8, and INRA (2018) 93 and 16.9. The FIBNUT proposal overpredicted MEI by 2% and NRC (2016) by 4%, while AFRC (1993) underestimated by 12% and INRA (2016) by 15%. The mean square prediction error (MSPE) with the FIBNUT proposal was much smaller than with AFRC (1993), NRC (2016) and INRA (2018) (105 vs. 241, 150 and 360, respectively). The majority of MSPE for the FIBNUT proposal was from the random error (71%), while this value was smaller for AFRC (1993), NRC (2016) and INRA (2018) and (31%, 47% and 25%, respectively).

Conclusion
The FIBNUT proposal could predict ME requirements of beef cattle more accurately than AFRC (1993), NRC (2016) and INRA (2018).

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015 (Invited Speaker)

Modelling rumen microbial protein synthesis in beef cattle

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Application
Revised model for prediction of rumen microbial protein synthesis in beef cattle.

Introduction
Requirements for digestible undegradable dietary protein depend on estimates of rumen microbial protein synthesis. There have not been new experimental observations with UK animals and diets since earlier models, so we reviewed developments in other national systems.

Review
The most recent literature review of microbial protein synthesis in beef cattle (Galyean and Tedeschi, 2014) resulted in lower estimates. The UK Feed into Milk (2004) system predicted rumen passage rates from level of feeding and used those to estimate ATP production and hence microbial protein synthesis. Whilst there are updated equations for predicting passage rates in the INRA (2018) model, incorporating more observations, estimates are similar, and they are mostly based on studies with dairy cows. We ran estimates of microbial protein synthesis for a series of commercial beef diets suggested by our industry partners. Relative to Feed into Milk, estimates were 0.95 (s.d. = 0.015), 1.02 (s.d. = 0.017), 1.06 (s.d. = 0.064), 0.92 (s.d. = 0.031) and 0.78 (s.d. = 0.015) for ARC (1980), ARC (1984), AFRC (1992), INRA (2018) and Galyean and Tedeschi (2014) models respectively. The latter model is the only one developed specifically for beef cattle and

so we sought to understand the lower estimates. Feed into Milk assumed a fixed N content of 100 g/kg in microbial DM and we found no evidence of systematic differences between microbial samples isolated from dairy or beef cattle.

Conclusion
The Feed into Milk model was verified by reference to the range of values in the literature and we propose a similarly pragmatic approach to adoption of that model for beef cattle with a correction factor to reduce estimates of microbial protein synthesis, either directly or by reducing estimates of rumen passage rates. There remains a lot of unexplained variation, which has large implications for the efficiency of use of dietary Nitrogen.

Acknowledgment
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016 (Invited Speaker)

Dairy cows of the future

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Dairy cows being milked in the UK are the result of farmers' responses to market signals and their own resources, breeding companies responses to farmers signals and farmers own desires. During 1980's there were more than 20 breeding companies leading to a wide variety of cow types within the Holstein Friesian breed. Consolidation means there are now a handful and so offerings are more restricted leading to a less variable Holstein type. Farmers and breeding companies responded to the economic circumstances of the day and the UK now has a national herd with an average yield over 8000 kg and good metrics for health, fertility and disease resistance.
However, economic and social circumstances have begun to change since the retailers have become the voice of the consumer in many supply chains. Consumer demands have led to a greater selection pressure being placed on non-production traits such that Profitable Lifetime Index used by most dairy farmers to choose bulls has less than 50% emphasis on production.
The recent price spike in energy costs and uncertainty about future prices has led to an immediate and large surge in interest for traits that were already being considered for inclusion in selection decisions. The UK index offering has included Feed Saved based on feed intake records from the SRUC Langhill lines of dairy cows and Maintenance based on predicted mature cow size from linear type measures on bulls offspring. Genomics has allowed the rapid dissemination of superior genes for these traits despite limited recording.
This high demand for 'efficiency', however that is defined has led to questions on the role of cow size in a modern dairy industry that is, and will continue to be, constrained by energy costs. Predictions of cow size based on current inseminations shows that the national herd continue to rise in size at around 4000 tonnes per year. The average cow mature weight is around 700 kg.
Genetic tools include genomic selection. Most improvements are down the sire line. Cow selection intensity may increase due to sexed semen and use of advanced reproductive technologies such as ovum pick up and in-vitro fertilization. This would allow greater emphasis on cows to suit specialized production systems.
The cow of the future will be the same or better than the cow of the current and she will be smaller and therefore more efficient in utilizing feed and have lower greenhouse gas emissions intensity. The emphasis will move from profit at market costs to profit at planet and society costs. A pertinent question to ask is how are farmers going to be paid and by whom to alter their selection directions?

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017 (Invited Speaker)

Technical considerations towards commercialization of porcine respiratory and reproductive syndrome (PRRS) virus resistant pigs

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The identification and introduction of disease resistance genes in livestock not only provide health benefits to animals but opportunities for breeders and farmers to meet the growing demand for high-quality meat and milk while reducing agriculture's footprint on the environment. As traditional methods of classical breeding and selection for trait improvement are slow, progress in: (i) understanding host gene function and pathogen interactions, (ii) inexpensive and rapid DNA sequencing, and (iii) robust gene editing like CRISPR-Cas provide new tools to accelerate discovery and deployment of disease resistance alleles in livestock. To this end, academic groups have discovered that modification of the CD163 gene in pigs can confer resistance to the virus that causes porcine reproductive and respiratory syndrome (PRRS). As a global supplier of high genetic merit livestock genetics, Genus plc and its pig division PIC (Pig Improvement Company) with Genus R&D are using gene editing, DNA sequencing, and bioinformatics to simultaneously generate and introduce a single modified CD163 allele across four genetically diverse porcine lines of commercial importance to prevent PRRS virus (PRRSV) infection. Today's presentation will review a commercial-scaled gene editing program including guide selection, on- and off-target screening pipeline, animal production and screening, and PRRS virus disease challenges to generate a founder population of PRRSV resistant pigs that will provide important benefits to animal health and food chain value once approved for commercial sale and export.

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018 (Invited Speaker)

A case report of dairy herd reproductive efficiency within all year round calving herds

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Herd reproductive efficiency and breeding goals are critical to dairy herd sustainability. Herd reproductive programs can affect a dairy enterprise's economic viability, environmental responsibility and indeed social acceptability. Poor reproductive performance increases environmental overhead by prolonging lactation thereby reducing yield and feed efficiency by not returning to peak milk in a timely fashion. Poor reproductive performance increases the risk of involuntary culling and reduces output of calves born. Thereby increasing the need for additional replacement of animals which impact greenhouse gas emission without production offset and demand larger investments in heifer rearing facilities, presently the second largest cost within many dairy enterprises. Indeed many studies demonstrate the economic, lands paring and carbon footprint benefits of rearing heifers to first calve at 22–26 months of age. To mitigate the effects of poor reproduction, increased use of hormonal intervention to facilitate fixed time artificial insemination may be undertaken, however routine use of hormonal therapy has been highlighted as a potential ethical dilemma within dairy practice.

Excellent reproductive efficiency within herds grants an opportunity for increasing cow lifespan by increasing the number of lactations a cow has prior to herd removal and thus reduce the number of replacement animals required to sustain herd size.

More recently the concept of creating a high fertility cycle within herds has been described, linking body condition score change and health events in the during the periparturient period, and reproduction, in which lactation dairy cows that become pregnant by 130 days in milk have less body condition score gain during the during the current lactation, lose less body condition score post calving, experience fewer transition cow related disorders, have greater first insemination conception rates and fewer early pregnancy losses following establishment of pregnancy.

Herd data presented in this case summary was taken from all year-round calving herds participating in a commercial reproductive management program for oestrus detection, insemination and reproduction data recording operated by Genus ABS. This involves a daily farm visit by a trained reproduction management specialist using talk chalk to identify cows in oestrus, including a manual examination per rectum of the reproductive tract of cows identified by changes in chalk distribution, indicative but not conclusive of the animals expressing oestrus since the previous visit. Cows determined as in oestrus are then artificially inseminated. Data collection includes including dates of calving, oestrus, insemination, dates and outcomes of pregnancy diagnosis, dates of drying off, do not breed designation and date of herd removal. Data is entered into a cloud-based computer software bureau (BoviSync, Dairy LLc, Eden, WI).

Two factors that determine reproductive efficiency (i.e., the rate at which eligible cows become pregnant, typically reviewed over a 21-day period) within a dairy herd, are the submission rate (i.e., the rate at which eligible cows are inseminated) and conception to artificial insem-

ination (i.e., the proportion of inseminated cows that become pregnant). Within the presentation reproductive efficiency figures such as those forementioned, reproductive outcomes of hormonal intervention programs and herd exits will be reviewed, demonstrating current herd reproductive key performance indicators utilised and trends for further consideration within the Genus Breeding Ltd RMS data set.

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019 (Invited Speaker)

Identifying trends in phenotypic and genetic lifespan in dairy cows over the past 15 years

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Application
Disentangling the genetic and environmental effects of lifespan to compare cows within contemporary groups.

Introduction
The high emphasis of lifespan in the PLI has led to strong improvements in cow breeding values for lifespan over the past number of years. Contrary to these improvements, the phenotypic length of time cows survive on farm has decreased. However, over this period, the reasons that cows exit the herd have changed drastically. This study looks to strip out some of these environmental decisions to study the relationship between genetic and phenotypic trends for lifespan.

Materials and methods
Data were extracted from milk recorded organisation data from 998 CIS herds in the UK. Data was restricted to cows born after 1st January 2007 and cows were only included in the analysis if they died on the farm, exited the herd to be slaughtered or were still alive. Cows were then grouped into quartiles according to the sire's PTA for lifespan, where quartile one included sires' of cows with the highest lifespan PTA and quarter four including sires' of cows with the lowest lifespan PTA. A Cox proportional hazard model similar to Cox (1972) was ran to account for lifespan quartile of the sire, herd effect and year of birth effects. The results of the models were then plotted for the highest and lowest quartiles according to sire lifespan PTA.

Results
Across all timepoints cows in quartile one, cows had better survival than in lower quartiles. At 24 months of age, survival was 2.78% greater in quartile one than in quartile four. At 65 months of age (approx.. 3.5 lactations assuming cows first calve at 24 months and maintain a 365-calving interval), the difference in survival between quartile one and quartile four increased to 26.87%. At 3.5 lactations, the difference in survival between the two groups was 221 days.

Conclusion
Despite the length of time cows remain on farm having reduced in recent years as the genetics for lifespan have increased, cows whose sires have higher values for lifespan live longer than their contemporaries. This confirms that genetic evaluations for lifespan are an accurate predictor of the length of time that cows stay alive for with sires of higher lifespan producing daughters which live longer than their contemporaries. Therefore, selection on lifespan would be expected to have a significant impact on the dairy economics by improving the productive life of the animal and reducing the need for replacements, thus allowing more voluntary culling and less involuntary culling.

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020 (Invited Speaker)

Studying global cattle genealogy using tree sequence

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Application
This study provides a more profound comprehension of the demographic history and population structure of Bos indicus cattle. Since the subspecies is used mainly in tropical and low-input dairy systems, this knowledge can benefit the development of better-fitted breeding strategies leading to improved efficiency and sustainability in such scenarios.

Introduction
Modern cattle are subdivided into two subspecies, *Bos taurus* (taurine cattle) and *Bos indicus* (indicine cattle). The differences between the subspecies are driven by distinct demographic history and selective breeding. Taurine cattle emerged through domestication in the Fertile Crescent of the Middle East (Pitt et al., 2019) and the migration of agriculture-based human populations through Europe. In Europe and later in the Americas, specific taurine breeds emerged through directional selection for different use (beef or dairy) and environments. The intense selection and dissemination culminated in the prevalence of some of these breeds worldwide. On the other hand, indicine cattle emerged later in the Indian subcontinent (Mwai et al., 2015), where it was subject to different (challenging) environmental conditions and was bred extensively until recently.
While taurine breeds show more outstanding production and adaptation to intensive production environments, some indicine breeds perform better on pasture with low nutritional needs and are remarkably tolerant to heat and parasites. When crossed, taurine-indicine animals can be of huge value to farmers in the Global South, such as in Brazil. This value stems from breed complementarity and heterosis that drive high productivity combined with resilience. However, the genetic makeup of these crosses, and also of indicine cattle, is largely unknown.
We aim to address this gap and draw deeper and more detailed information about population genomics and genetic makeup of Bos indicus and taurine-indicine crossbred cattle.

Materials and methods
We inferred cattle whole-genome genealogy to investigate the genomic similarities and differences between global cattle populations across both subspecies using tree sequences (Kelleher et al., 2016).
We analysed the 1000 Bull Genome Project public data set (Run8). For this analysis, the data set was restricted to 1181 diploid whole-genome sequences (42M SNP on 29 autosomal chromosomes) including 21 taurine, 6 indicine breeds, and 26 taurine-indicine crosses. Among the indicine breeds were Gir, Nellore and Brahman. Cattle whole-genome genealogy was inferred using *tsinfer* and *tsdate*. Further analysis of the tree sequence was performed using the python package *tskit*.

Results
The resulting tree sequences contained 11,997,863 local trees, 257,997,301 edges, and 269,727,991 mutations, all efficiently stored in 18.7 Gbytes. The trees include information about the history of sampled taurine and indicine cattle genomes, down to each genomic region, indicating a profound profile of the evolution of both subspecies and breeds within the subspecies.

Conclusions
Our work demonstrates the excellent data compression of the tree sequence and gives essential insights into the evolutionary history of global cattle.

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021 (Invited Speaker)

Understanding Veterinary Public Health & One Health and the contribution of vets (working with others) to wider society

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The traditional veterinary clinical role of treating all animal species is well known and appreciated by the public. However, the benefits of non-clinical veterinary work are not widely understood by society.
All veterinarians, **collaboratively with others**, provide benefits for animals, humans and the environment they share. Vets' contribution to the 'One Health Concept' (or Veterinary Public Health) has been acknowledged as such by a number of international bodies.

VPH is defined by the World Health Organisation (WHO) in 1999 and endorsed by the World Organization for Animal Health (WOAH formerly OIE) and the UN Food and Agriculture Office (FAO) as:
"....the sum of all contributions to the physical, mental and social wellbeing of humans through an understanding and application of veterinary science."
This definition of VPH is embedded within the One Health concept whose operational definition was revised in December 2021 in the One Health Joint Tripartite (FAO, OIE, WHO) and UNEP statement (December 2021):

> "**One Health** is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems".

In the Vet Futures Report' (2016), the UK Royal College of Veterinary Surgeons (RCVS) and British Veterinary Association (BVA) acknowledged more needs to be done in promoting different career paths and the wider roles of vets in society.
In paralel, amongst many other initiatives in the UK, the Veterinary Public Health Association (VPHA) and Association of Government Vets (AGV) organized in 2016 joint Conferences themed '*VPH Hands on-making a difference together*' *and* '*Sustainable Veterinary Surveillance in Global Context*'. They explored with delegates whether different audiences such as politicians, business, industry (farming, trade, food), other professionals and the public need the different messages about vets wider involvement and contribution to society. The challenge was set up to create important short messages encompassing **ALL** veterinary work on one, maximum two pages.
Following on VPHA designed in 2017 the two page document with an illustration with the two heads, four arms veterinarian on '*VPHA's Position on Veterinarians' contribution to the wider society*'. The document as such has been used and distributed at varios conferences & meetings including to some Veterinary Educational institutions. In some Vet Schools in UK the illustration has been used as a logo for 'VPH/ One Health subject'.
To move on veterinarians, **jointly with other professions**, are moving towards greater understanding of recognizing each other contribution to One Health & Veterinary Public Health. There has been also an increased effort of communicating their benefitial contribution to protect people, animals and environment.

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022 (Invited Speaker)

Veterinary public health and small animal practice: Less known examples of the benefits of networking and working with others

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By treating an individual animal or a group of animals both clinical and non-clinical veterinarians, working collaboratively with others, contribute to the well-being of animals, people and the environment they live and share in the developing and developed world.
Veterinarians have always been involved with:

- Negotiating, drafting and upholding necessary legislation and international standards, including sustainable policy development, implementation, review and risk analysis (risk management, assessment and communication)
- Global food security (quantity, quality and safety) and consumer protection
- Cutting edge science, discovery and teaching
- Protecting public health and animal health by officially controlling diseases relevant to public health and animal health (One Health) and protecting animal welfare. Protection from fraudulent activities
- Facilitating economic growth (small & large businesses) through sustainable farm/ food production, trade (certification) of animals and Products of Animal Origin (POAO)
- Preserving diverse production (rare breeds, traditional food production)
- Communicating important messages to interested parties: public and animal keepers (food producing and companion), industry (agri-food and others), politicians, civil servants, other scientists/professions (lawyers, economists, medics, animal scientists, environmentalists, microbiologists, statisticians etc.)

In a world without veterinarians:

- Animals and people would suffer increasingly from famine, disease and death
- The Environment would see higher levels of pollution
- Economic growth would stagnate in many societies with no sustainable agri-food production and trade
- Some societies would see a lack of food diversity and cultural damages due to the loss of traditional farming and food production

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023 (Invited Speaker)

AMR and one health

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From a public health perspective, antimicrobial resistance (AMR) in animals including livestock can jeopardize human health, due to the potential dissemination of AMR pathogens to humans and the environment. The nature of AMR in livestock microbiomes and the routes of acquisition of AMR genes, especially in ruminants is largely unknown. A systems level, multidisciplinary understanding of AMR and its acquisition in livestock microbiomes encompassing the principles of the One Health Initiative may help reduce livestock AMR footprint. *One Health recognizes that the health of humans, domestic and wild animals, plants and the wider environment and their ecosystems is closely interconnected and interdependent. Therefore the implications of this need to be considered, particularly with respects to the One Health challenge of AMR. This is because* the economic impact of uncontrolled AMR will result in a dramatic rise in health expenditures and damage to food systems and livelihoods, leading to increasing levels of poverty and inequality.
Here, I present some system level data using a Brazilian study to highlight the problem of AMR in the human-veterinary-environmental interface and what this means for One Health. I also hypothesise that plant feed and plant based livestock feed and their microbiomes may play a role in AMR acquisition and spread.
The scale of antibiotic use in agriculture and the large numbers of livestock involved provide a significant route for dissemination of antimicrobial resistance genes (ARGs) carrying bacteria to carcasses, the environment and subsequently to the human population. In this study, we assessed AMR in livestock animals, the farm environment and human/farmer microbiomes in farm ecosystems, ranging from extensive to intensive with and beef and dairy cattle in 5 major food producing states in Brazil
Through metagenomic analysis, we reveal a great diversity of (ARGs) across all states and farms with tetracycline resistant genes making up ~50% of total ARGs across all microbiome types. Of concern was observed resistance to many last resort antibiotics including vancomycin, quinolone and colistin identified in ruminal, environmental as well as human samples in 3 of the 5 states with a positive correlation (r^2 = 0.712) of ARG abundance and diversity to routine antibiotic use irrespective of farming systems. Phylogenetic characterisation of vancomycin resistance genes found from ruminant faeces, farm soil and farmer's nasal swab from the same farm suggest the possibility of horizontal gene transfer between microbiome types.
Although plants, plant based livestock feed were not directly investigated in this study, these findings raise the question of their role in the acquisition of and spread of AMR genes given their interconnectedness with the soil environment. It also provides evidence for the study of phytobiomes (plant situated in its specific ecological area, including its environment and the associated communities of organisms which inhabit it) and their influence on AMR as a One Health risk.

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024 (Invited Speaker)

Microalgae as feed

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One Health challenges which include emerging, re-emerging, and endemic zoonotic diseases, neglected tropical diseases, vector-borne diseases, antimicrobial resistance, food safety and food security, environmental contamination, climate change and other health threats shared by people, animals, and the environment require an integrated, unifying approach that aims to sustainably balance and optimize global health of human-animal-environment and their ecosystems.
In the rumen, dietary fermentation provides energy and protein to the host through volatile fatty acids (VFA) and microbial protein production. However, methane production contributes to greenhouse gas accumulation and represents a loss of dietary energy. In sheep, microalgae supplementation has shown to decrease methane production and increase VFA concentrations in the rumen, with changes

in pH and VFA profiles. Therefore, microalgae are considered to be a possible solution to food security-related problems stemming from land scarcity and climate change within the agricultural sector.
To investigate this hypothesis that microalgae may hold a solution for One Health Challenges, we have assessed the effects of supplementing microalgae oil at different levels on feed intake, growth and methane emissions of finishing lambs. We used sixty-four male lambs, Texel crossed, blocked into 16 groups according to age and body weight (BW). Within each group, lambs were assigned to one of four dietary treatments. All treatments were fed TMR diets with 50:50 grass silage and concentrate (DM basis). Diets included: 0.00% (Control; TMR-C), 0.54% (Low; TMR-L), 1.08% (Medium; TMR-M) and 1.62% (High; TMR-H) microalgae oil. Daily feed intakes and weekly BW were recorded from individually penned lambs during 76 days. Average daily gain (ADG), dry matter intake (DMI) and residual feed intake (RFI) were individually calculated. At day 55 of treatment, methane emissions were measured from 24 lambs (4 groups) in 6 individual respiration chambers during 3 days.
In summary, microalgae oil supplementation decreased DMI ($P = 0.002$), ADG ($P = 0.010$), and methane production ($P = 0.009$) and yield ($P = 0.041$), without affecting RFI ($P = 0.514$). Feed intake decreased 17.5% in TMR-M ($P = 0.004$) and 18.9% in TMR–H ($P = 0.002$) compared to TMR-C. Daily weight gain decreased 23.2% ($P = 0.010$) in TMR-M and 21.8% ($P = 0.016$) in TMR–H compared to TMR-C. Lambs fed TMR-H had 21.5% lower methane production ($P = 0.003$) and 20.3% lower methane yield ($P = 0.014$) than TMR-C lambs. We concluded that microalgae oil supplementation at high levels in a TMR diet decreases methane emissions, however, microalgae oil at medium and high levels reduced DMI and ADG without affecting feed efficiency (RFI) in finishing lambs.
These results suggest that microalgae as feed have a potential in tackling the One Health challenges of food security and climate change simultaneously.

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025 (Invited Speaker)

Grassland-soil-animal interactions

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Grassland phytobiomes focus on the link between organisms interacting within the soil, this is essentially the soil food web, and the ecosystem functions that are driven by soil fauna. The importance of soil biodiversity within soil health is commonly overlooked. Also, the concept of soil health is less frequently prioritised within grassland systems due to the inherent stability of these environments; however, it should be monitored to assess the impact of change (in management or climate). Soil biodiversity can also act as an indicator of soil health, with a fully-functional and biodiverse food web exemplifying a healthy soil and a synergy between plant-soil-animal-interactions. The abundance and biomass of soil animal communities may exceed aboveground biodiversity by several orders of magnitude particularly in grassland systems. The soil habitat and soil fauna within it are unique – as soil fauna are completely immersed in the environment they live in, surrounded by their food, living space and excretion products with minimal capacity for emigration or immigration. This is why soil fauna have such a large impact on the ecosystem services provided by the soil. The relationship between soil biology, organic carbon and soil structure determines the performance and resilience of the soil system.
Currently, grassland soils have the highest carbon stock of any UK habitat. They are often seen as an example of the typical landscape within the UK, as well as being part of our cultural heritage particularly in extensive livestock systems. Livestock grazing has been shown to exert a strong, but variable, influence on species richness of soil fauna. An example of this is the positive but also negative impact cattle grazing may have on earthworms – the positive increase in food availability from the livestock's excretion products and potential increases in soil organic matter alongside the negative changes in soil pH and compaction risk. Increased abundance of soil fauna has also been found to have positive effects on aboveground plant biomass and increasing the amount of organic carbon within soils, leading to potential productivity increases within pastures. The optimal balance of soil fauna in terms of improving ecosystem function is still unknown, however maintaining and increasing diversity is vital for nutrient cycling, retention, improved soil structure, infiltration and water holding capacity as well as carbon sequestration. Understanding this positive feedback loop between soil fauna and plants is key to building increased resilience within grassland systems and promoting these plant-soil-animal interactions.

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026

Impacts on the chicken faecal microbiome as the result of various early life management treatments post-hatch

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Application
This study will identify and characterize the faecal microbiota of chicken reared using five early life management approaches; and analyse the benefit any of these approaches to the poultry industry.

Introduction
The management of poultry around the United Kingdom has developed over decades. Improving welfare of chicken and a growing demand of a protein source, this study was designed to benefit current poultry industry practices. Commercial practices used by many poultry producers hatch fertilized eggs in hatcheries and transfer chicks to broiler houses where they are first introduced to food and water (CFoC, 2019). Early provision of feed and water is beneficial to birds when comparing growth rate and feed intake; although few differences can be identified in the microbiota (Ivarsson et al., 2022).

Materials and methods
Faecal and litter samples were collected over five occasions from thirty pens assigned to five early life treatments: Control (commercial standard) (Ctrl), wet food at broiler house (WFBH), food and water at hatchery (FWH), birds hatched at broiler house (HaBH) and water at hatchery (WH). Each treatment benefits the birds in welfare, from reduced stress during transport to early access to feed and water. After combining pen samples, DNA was extracted and 16S sequencing was carried out via PacBio, gaining data at a species level. Data was processed using Qiime2, filtering the top 95% abundant reads for statistical analyses in R using the 'vegan' package.

Results
Diversity increases in faecal samples with age developing from a Streptococcus dominated community towards a Lactobacillus dominated community; whilst communities across litter samples are more diverse at 2 days old, a mixture of Enterococcus, Escherichia-Shigella and unknown species, developing to a very diverse community including Corynebacterium, Lactobacillus, Brachybacterium and Staphylococcus. Most ages we see the FWH and WFBH, along with WH and Ctrl treatments appear to present similar abundances in faecal samples. ANOVA analysis suggest significant differences between the means of each treatment, whilst the Bray-Curtis Dissimilarity index suggest fewer differences in the shared species.

Conclusions
Faecal samples present a dominating abundance of Lactobacillus, especially during the latter ages, where FWH and WFBH, along with WH and Ctrl treatments present similar communities, as expected diversity increases over time with high levels of shared species.

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027

Impact of low crude protein diets diluted with wheat differing in particle size on gizzard histology of growing broilers

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Application
To better understand the impact of diet structure on the gizzard histology of broiler chickens.

Introduction
Most studies on the influence of diet structure on gizzard development have focused on gizzard mass and reported the improved gizzard mass with an increased particle size of poultry mash diets. A little attention has been devoted to its histological development. The study aimed to investigate how varied diet structural texture affects gizzard histology in modern broiler chickens when fed on low crude protein diets.

Materials and methods
A day-old 336 Ross-308 male broiler chicks were equally divided into four dietary treatments allocating 7 replicates per treatment with 12 chicks each. The wheat differing in particle sizes was included post-pellet. Four dietary treatments; A: commercial diet with standard crude protein 22.50%, B: A+20% post pellet wheat of GMD 578 microns crude protein 20.25%, C: A+20% wheat of GMD 1326 microns crude protein 20.25%, and D: A+20% whole wheat crude protein 20.25%, were fed ad libitum to the birds up to day 21. Data on gizzard histology were collected on days 14 and 21 from cervically dislocated two birds per pen and analysed by one-way ANOVA. Means were differentiated by the LSD test at $P \leq 0.05$.

Results
The mucosa of lamina propria at day 14 on a standard protein diet increased ($P \leq 0.05$) compared to low protein diets with wheat GMD 578 and 1326 microns. However, no difference ($P > 0.05$) in the mucosa of lamina propria on days 14 and 21 and the extent of tunica muscularis on day 21 was observed between a standard protein diet and a low protein diet with whole wheat inclusion.

Conclusions
A diet with reduced crude protein by 10% with the inclusion of 20% whole wheat does not compromise the gizzard histological development, which might increase the digestive efficiency of broilers on low-density crude protein diets.

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028

The use of field peas to substitute soya in broiler finishing diets

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Application
The study aimed to reduce the dietary inclusion rate of high protein soybean meal in the finishing ration of commercial broilers within a commercial supply chain by replacing soybean meal with field peas. Reduction in the utilisation of soybean meal, and replacing this with a UK-grown crop provides opportunities for environmental and economic benefits.

Introduction
A feeding experiment was carried out which incrementally reduced soybean meal inclusion rate in the finishing ration of broilers using UK grown field peas to improve the sustainability and economic resilience of poultry production, with the aim of doing so without compromising production targets.

Materials and methods
Four hundred Hubbard CYJa57 broilers that had been reared on standard diets to 25 days old were fed one of four experimental finishing diets (100 birds/diet, 4 pens/diet) until slaughter (day 28 to 53); 1) P0; control, 0% substitution of soybean meal, 2) P25; 25% substitution of soybean meal, 3) P50; 50% substitution of soybean meal or 4) P75; 75% substitution of soybean meal. Diets were formulated to have similar energy densities, and protein and fat concentrations. Soybean meal was predominantly substituted with a white field pea, but to balance the protein high protein sunflower meal was added to all diets and fishmeal was added to the P50 and P75 diets. The feed intake, live weight (LWt) and feed conversion ratio (FCR) of broilers were recorded. Data were analysed using ANOVA with polynomial contrasts (Genstat, 19th ed.), where a P value < 0.05 was considered significant.

Results
The bird welfare scores were same across all diets, with the exception that one bird on the P75 diet died. The P0 and P75 diets resulted in the highest final empty LWt and total LWt gain, and the lowest final live weight and total LWt gain were associated with P50 diet, with the P25 diet being intermediate ($P < 0.05$). However, birds on all diets exceeded the genetic target for LWt gain. Mean total and daily feed intakes, average daily gains and feed conversion ratios (FCR) during the finishing phase were similar across all diets.

Conclusions
Incremental substitution of up to 75% of the soybean meal in the finishing ration of broiler diets was successfully achieved using predominantly field peas without compromising bird welfare, feed intake or FCR. There were significant differences in final LWt of the birds, yet all birds exceeded the genetic targets for LWt. Therefore replacing soybean meal with UK-grown peas resulted in bird performance that was as good the industry standard diet.

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029

Differential sensitivity to processed Mezquite from two areas of Mexico on broiler chicken performance

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Application
Post-harvest processing can overcome the negative effects of mesquite pod flour (MPF) on broiler chicken performance, but is dependent on the region of Mexico the pods were grown.

Introduction
Mezquite (genus Prosopis), is an under-utilised leguminous tree, whose pods can be ground to a flour containing 7-17% protein (Ellsworth et al. 2018). We previously showed (Bone et al, 2021) that Kenyan MPF reduced growth in broiler chickens following a 15% substitution into a wheat-based feed, likely due to the presence of antinutrional factors (ANFs). This trial evaluated the effect of heat processing and inclusion of exogenous phytase on a 15% inclusion of MPF from two distinct areas of Mexico, Sonora and Sinaloa.

Materials and methods
Six-day old Ross 308 broiler chickens ($n = 144$) were fed one of six diets ($n = 6$ pens per diet, 4 birds per pen). The control birds were fed a wheat-based diet (CON) which was unprocessed, or the same diet with a 15% substitution of roasted wheat plus a phytase superdose (Quantum Blue, AB Vista) at 1500 ftu/kg (CONPRO). The experimental diets had a 15% inclusion of raw MPF from Sonora, Mexico (SON) or from Sinaloa, Mexico (SIN), or the same MPFs processed by roasting at 140 °C for 10 minutes with inclusion of phytase (SONPRO or SINPRO). All diets were formulated for equivalent crude protein and energy contents. Feed intake and body weights (per pen) were recorded twice per week. Birds were culled on day 35 and the right breast muscle and liver dissected and weighed. Data was analysed by two-way ANOVA (diet x processing) followed by post-hoc bonferroni tests (Genstat 19th edition), and significance was taken at $P < 0.05$.

Results
There were significant interactions between feed and processing for final body weight ($P = 0.006$) and FCR ($P = 0.049$). Both unprocessed mesquite diets (SON and SIN) reduced final body weight and increased FCR, while processing countered these effects for SON, but not SIN, and had no effect on the CON diet. Total feed intake was increased for all diets containing mezquite ($P < 0.05$). Birds fed SIN diets had smaller breast muscles as % of body weight ($P < 0.05$), while liver weights were unaffected ($P = 0.98$).

Conclusions
Utilisation of MPF by broiler chickens is affected by geographical location and processing. This is likely due to differing levels of environmental stress, which affect the ANF contents, some of which are sensitive to processing and/or phytase inclusion.

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030

Growth and egg production performance of Japanese quails (*Coturnix coturnix japonica*) fed diets containing graded levels of ginger waste meal (*Zingiber officinale*) as a partial replacement for maize

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Application
Ginger waste meal was used to substitute maize (30%) as a major energy source in the diets of growing and laying Japanese quails.

Introduction
Quails are small game birds that are suitable for meat and egg production on a commercial scale (Oyewuchi et al., 2013). They have a short incubation period, attaining sexual maturity within a short period of time. They are able to have about four generations in a year (Saidu et al., 2014). They have favourable characteristics such as fast growth rate, high number of egg production of about 300 eggs per annum, early sexual maturity of about 6 weeks, They consume only about 20-25 g of feed per adult per day, resulting into less feed cost, and are not easily brought down by common poultry diseases (Aygun and Sert, 2013).

Materials and methods
Two hundred and eighty-eight (288) two week old Japanese quails of mixed sexes with an average initial body weight of 36.20 ± 0.05 g and one hundred and twenty (120) six week old female Japanese quails were used for the growth and laying phases respectively. The birds were randomly assigned to four dietary treatments with four replicates of 18 birds per replicate during the growth phase and 10 birds per replicate during the laying phase. The treatments were designated as T1, T2, T3 and T4 containing ginger waste meal at 0%, 10%, 20% and 30% in a completely randomized design experiment. The crude protein levels were set at a mean average of 24 and 20% for the growth and laying phase respectively, the crude fibre and metabolizable energy were 5.14–5.17% and 2323–2760 Kcal/kg respectively, feed and water were given ad-libitum. The growth phase lasted for four weeks while the laying phase lasted for twelve weeks. Data collected during the feeding trial were initial body weight, final body weight, average weekly feed intake, body weight gain, feed conversion ratio, carcass characteristics, nutrients digestibility, egg production and internal/external egg quality parameters. All data collected were subjected to a one way analysis of variance (ANOVA) using SPSS (2017 version). Duncan Multiple Range Tests were used to separate means where differences occurred.

Results
The results obtained revealed that all parameters evaluated were not significantly ($p > 0.05$) influenced except for average feed intake. The results obtained for nutrients digestibility showed that there were no significant ($p > 0.05$) differences in the apparent digestibility of the nutrients except for crude fibre and nitrogen free extract. The results of carcass characteristics revealed that the treatment had no significant ($p > 0.05$) influence on all the parameters measured. The results of the egg production and egg quality revealed that there were no significant ($p > 0.05$) differences among the dietary treatments except for yolk weight, yolk diameter, egg width and egg volume.

Conclusions
From the results obtained in this study, it was concluded that ginger waste meal can replace maize up to 30% with no detrimental effects on growth and laying performance of Japanese quails.

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031

Carcass quality of broiler chicken fed varying dietary walnut (*Plukenetia conophora* MULL. ARG) and melon (*Citrullus colocynthus* (L.) SCHRAD). seed meal

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Application
The study intend to provide biological material that is capable of elongating the storage period of broiler chicken.

Introduction
The rich nutritional profile in meat which are protein, minerals, fat and oils and little carbohydrate makes chicken highly perishable and deteriorates rapidly (Devatkal et al., 2012). Therefore, this study was aimed at assessing the dietary supplementation of walnut and melon seed meal on carcass quality of broiler chicken.

Materials and methods
Seven isonitrogenous (19%) and isocaloric (2931.5 kcal/kg Metabolizable energy) diets were formulated. Basal diet (T1) had no walnut or melon seed meal supplementation while other diets contained supplemental 2,4 and 6 g/kg of walnut seed T2, T3, T4 and melon seed meal T5, T6 and T7, respectively. Arbor acre broiler chicken (n = 336) weighing 500 ± 0.5 g and aged 28 days were allotted in a completely randomised design to the diets for four weeks.

Results
Primal cut were significantly ($p < 0.05$) increased by the dietary inclusion of walnut and melon seed meal levels except thigh and breast. Broiler chicken fed cooked melonn seed meal at 4 g/kg had significantly ($p < 0.05$) higher drum stick (10.28%), wings(8.36%) and back (13.11%) while the least were for control 7.73, 6.79 and 8.93%, respectively.

Conclusions
Carcass quality of broiler chicken on various treatment were enhanced by dietary supplementation of both walnut and melon seed meal due to their natural antioxidant property (Olufeko et al., 2020).

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032

Assessing the growth performance of broiler chickens fed diets containing varying levels of date by-products as a partial replacement for maize

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Application
The growth performance of broiler chick ens is influenced by feeding different levels of date (*Phoenix dactilifera*) by-products.

Introduction
Low availability of suitable feed ingredients that can comfortably replace maize as an energy source has been a major hindrance that faces the development of the poultry industry in many tropical and sub-tropical countries, and this has necessitated the search for suitable non-

conventional feed ingredients to provide required nutrients for the birds (El-Deek et al. 2010). Date by-products are considered to be such a good ingredient that could partially alleviate feed scarcity and reduce environmental pollution (Al-Harthi et al., 2009). Therefore, this study aimed to evaluate the performance of broiler chickens fed date by-products at different inclusion levels.

Materials and methods
Five diets that replace maize at different date by-products (chaff with pit, after syrup extraction) inclusion levels (0%, 15%, 30%, 45%, and 60%) were formulated. A total of 250 one-day-old Cobb500 broiler chicks were randomly allotted to five dietary treatments with five replicates of ten birds each in a completely randomized design experimental layout. Data were recorded daily for feed intake (FI), and feed conversion ratio (FCR) while the final weight (FW) and weight gain (WG) were recorded at the end of each week. Data were analyzed using the GLM procedure in SAS 9.1.3. Means were separated using Tukey at a 5% level of significance.

Results
Date inclusion in the diet significantly ($p < 0.05$) decreased the FI, WG and increased the FCR as the inclusion of date by-products increased. The recorded poor performance with increased level of inclusion could be attributed to the high dietary fibre contained in date by-products compared to cereals, or perhaps as a result of phytochemical compounds contained in dates that interfere with the digestion and absorption of nutrients.

Conclusions
Date by-products can replace maize up to 15% and 30% at starter and finisher phases, respectively, in broiler chicken diets.

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033

Effect of tannia cocoyam corm based diet supplemented with selenium on physical performance in broiler finisher chickens

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Application
The drawbacks encountered in complete utilization of the nutritive value on processed cocoyam (CCYM) corm has triggered the use of alternative cost effective dietary strategy with antioxidants.

Introduction
The upsurge in the cost of feed and poultry product has resulted in search for alternative cheaper energy source, such as cocoyam corm (Ahaotu, 2018). Cocoyam contains phytochemicals which limits its use due to important roles on health status and metabolism (Ebenebe et al., 2019), therefore dietary supplementation with selenium alleviate the antinutritional effects in gastrointestinal tract with enhance digestibility and intestinal absorptive capacity (Zhang et al.,2011). Since selenium enhance protein uptake. This study was carried out to evaluate the combined effects of cocoyam diets plus selenium supplements on the physical performance and carcass characteristics in broiler finishers.

Materials and methods
Five processed cocoyam (CCYM) based diets supplemented with selenium at 0.5 mgse/kgdiet were manufactured, that comprised raw sundried and boiled sundried, both at 40% and 80% inclusion levels, and a control diet at 0% inclusion level. These five dietary treatments were offered for a period of three weeks, to Ross strain broiler finisher chickens ($n = 100$) at four weeks of age, with an average weight of 1.2–1.3 kg/bird. Birds ($n = 20$) were allotted to each treatment in two replicates with birds ($n = 10$) arranged in a complete randomized design. Physical performance parameters were measured. Carcass evaluation was conducted at the end of the experiment using chickens ($n = 3$) from each treatment. Data were analysed by analysis of variance (SAS) using General Linear Model and significant means separated by Duncans Multiple Range test.

Results
Higher total feed intake/bird ($P < 0.05$) value (3074.33 g) and better ($P < 0.05$) feed utilization (1.89) observed at 40% level of boiled cocoyam as compared to all other treatment groups, however feed utilization in birds on 40% raw cocoyam is similar to control. Liveweight,

dressed weight and breast weight of the broiler finisher indicated better weight development in treatment groups with higher ($P < 0.05$) values of 2815.0 g, 2129.0 g and 27.07 g/100 g respectively, on 80% boiled cocoyam. Abdominal fat levels indicated lower ($P < 0.01$) value (0.78 g/100 gLwt) on 80% level of raw cocoyam meal group of birds, as compared to control and other treatment groups. Combine effects of cocoyam and selenium apparently enhanced intestinal absorption, with consequent improvement on plumage and muscle growth.

Conclusions
Tannia cocoyam at 80% on boiled and 40% levels on raw sundried meals, both supplemented with selenium at 0.5 mgse/kg diet can be fed to broiler finishers for improved liveweight with excellent feathering, good fat content, and higher palatability plus better feed utilization.

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034

Sustainable broiler production with increasing phytase dose and reducing the use of inorganic P to further reduced phosphorus and nitrogen excretion

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Application
New generation phytase application can reduce phosphorus and nitrogen excretion in broiler production.

Introduction
Recent studies reported that a novel consensus bacterial 6-phytase variant (PhyG) was able to totally replace added inorganic P (iP) in broilers from day 1 and maintained performance (Marchal et al., 2021). The effect of increasing the phytase dose on P and N excretion in iP free diets need to be further evaluated.

Materials and methods
This study evaluated the effects of increasing dose level of PhyG on P and N excretion in broilers fed commercially relevant diets without iP from 10 days of age. Ross 308 male birds were used, with 8 treatments, 6 replicates per treatment with 20 birds per replicate. A basal diet (negative control, NC) was formulated with added 0.12% mono-calcium phosphate (MCP) in starter and without MCP in grower and finisher. The NC was supplemented with 250, 500, 1000, 2000, 3000 and 4000 FTU/kg of PhyG. In addition, a positive control (PC) diet was formulated by supplementing NC diets with MCP to provide 0.42%, 0.39% and 0.38% digestible P in starter, grower and finisher, respectively and calcium level was balanced by using limestone. A filler was included to maintain composition of major ingredients so all diets were iso-caloric and iso-nitrogenous. Diets were based on wheat & maize, soybean meal and canola. Celite was used as a digestibility marker in all diets. The analyzed phytate P levels across treatments were 0.33%, 0.31% and 0.28% in starter, grower and finisher diets respectively. Excreta samples were collected from 6–9, 17–20 and 31–34 days of age for P and N measurements. Data were analyzed across the 3 sampling points by one-way analysis of variance (ANOVA), using JMP statistical program and significance level was considered at $P < 0.05$. In addition, curve fitting was performed to model the dose effect of increasing phytase dose on P and N excretion.

Results
Phytase supplementation significantly reduced P excretion compared to PC diets. Across 3 ages, the 250, 500, 1000, 2000,3000 and 4000 FTU/kg phytase supplementation reduced P excretion by 55%, 64%, 66%, 69%, 72% and 74%, respectively; and reduced N excretion by 2.4%, 3.9%, 5.3%, 6.0%, 6.1% and 6.2%, respectively, in comparison to PC diets.

Conclusions
It can be concluded that increasing PhyG dose enhances sustainable chicken meat production via reducing P and N excretion in inorganic P free diets in broiler chickens.

Reference

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035

Co-supplementation effects of β-galacto-oligosaccharides and methionine on intestinal microstructure, and musculoskeletal development in broilers subjected to cyclic stress

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Application
The current study will help in improving productivity and profitability and decreasing managemental costs through dietary management of heat stress in broilers.

Introduction
Recently, it was demonstrated that co-inclusion of β-galacto-oligosaccharides and methionine improved the growth performance, blood metabolites and breast meat quality attributes in broilers reared under thermoneutral environment (Ahmad et al., 2022). Similarly, the co-inclusion also improved the bodyweight during fourth week and feed intake during in broilers subjected to cyclic heat stress (Rehman et al., 2022). In the present study, we further investigated the effects of co-supplementation of β-galacto-oligosaccharides and methionine on serum redox status, intestinal microarchitecture, goblet cell population, intraepithelial lymphocytes count and biometry of tibial bone and breast muscles in broilers subjected to cyclic heat stress. It was hypothesized that β-galacto-oligosaccharides and methionine synergistically counter the oxidative stress and assault to the intestine as induced by heat stress, resultantly improving nutrient utilization and musculoskeletal development in broilers.

Materials and methods
Day-old broilers (n = 288) were distributed in a 3×2 factorial arrangement (6 replica/group) with 3 levels of β-galacto-oligosaccharides (0%, 0.2% and 0.5%) and 2 levels of methionine (0.5% and 1.0%). The birds were subjected to cyclic heat stress (35 ± 1 °C; RH 65 ± 5%) daily for 8 hours from day 22 to day 35. On day 35, 2 birds from each replicate were killed for sample collection. . Blood samples were collected for determination of serum malondialdehyde and catalase levels. Breast muscle samples and portions of small intestinal segment were histomorphometry. Tibia bones were de-fleshed and air dried and processed for the determination of its weight, length, weight-length index, robusticity index, medullary canal and diaphysis diameter. Data (mean ± SE) were analyzed using the 3 × 2 factorial ANOVA with SPSS. Tukey's test was employed when the means of the treatments were significant at $P < 0.05$.

Results
No apparent effect of co-supplementation on MDA, catalase and histomorphometric parameters of the small intestine was noted except deeper jejunal crypts ($P < 0.05$) and higher ($P = 0.090$) goblet cell count along with significant ($P < 0.05$) β-galacto-oligosaccharides and methionine interaction in the birds fed a 0% β-galacto-oligosaccharides diet. The intraepithelial lymphocyte count was not affected by dietary intervention. Muscle fibre density ($P < 0.05$) and muscle fibre diameter ($P = 0.05$) were higher in the 0.5% β-galacto-oligosaccharides-supplemented group compared with other β-galacto-oligosaccharides-supplemented groups. However, supplementation of β-galacto-oligosaccharides and methionine had no significant main or interaction effects on bone health indices.

Conclusions
Co-supplementation of β-galacto-oligosaccharides and methionine did not show any promising effects on the studied parameters during heat stress. However, β-galacto-oligosaccharides have potential to improve jejunal microarchitecture the muscle histomorphometry in heat stressed broilers.

Acknowledgments
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036

Growth performance and antibacterial effect of *Raphanus Sativus* (Radish) extract on ceacal bacterial load of broiler chickens

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Application
Reduce the bacterial load (cfu/ml) in the ceca of broiler using radish extract at different dosage concentration and frequency of administration.

Introduction
Microbial colonization of the chicken gut has been an issue of concern for most poultry farmers whereas antibiotic feed additives developed antibiotic resistance and resulted in presence of antibiotic residues in poultry products Pan and Yu (2013) opined that the integrity of the intestinal structure and the gut micro biota play vital roles in nutrition, absorption, immunity, and disease resistance. Thus, this study aims to determine the effect of radish extract on the microbiota of caecum of broiler chicken.

Materials and methods
Six sets of a day- old healthy broiler chicken, under controlled diet and farm conditions were selected for this study with forty broilers in each set. Radish extract was administered at 10 mL/L and 15 mL/L twice and three times daily. 20% Enrofloxacin and Bromhexine hydrochloride solution was used as control for each groups. After 42 days of experimental feeding, the contents of the birds' ceca were collected for microorganism determination. Frequency and nature of microorganism were also obtained. Growth parameters were also obtained.

Results
Microbial load of broilers administered with radish juice twice daily ranged from $7.84 \times 107 - 2.60 \times 107$ cfu/ml while those with radish juice thrice daily ranged from $1.94 \times 107 - 1.75 \times 107$ cfu/ml whereas control group had a count range of $8.75 \times 107 - 8.56 \times 107$ cfu/ml. Microorganisms isolated include: Klebsiella pneumoniae (27%), Morganella morganii (24%), Bacillus subtilis (22%), Providencia rettgerii (5%), Staphylococcus saprophyticus (5%), Staphylococcus aureus (4%), Citrobacter fruendii (4%), Proteus mirabilis (2%), Micrococcus luteus (2%), Escherichia coli (2%), Providencia stuartii (2%). There was no significant difference ($p > 0.05$) in the growth performance parameters of the broilers at different dosage and frequency of administration.

Conclusions
This study suggests radish extract as an effective antimicrobial agent in reducing microbial load of the gut of broilers which consequently can lead to increased productivity, and feed – to – meat conversion ratio.

Reference

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037

Utilisation of Aloe ferox in the treatment and control of chicken ailments in rural communities

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Application
The findings may be used as a baseline when developing alternatives to commonly used additives to avert the occurrence of diseases or poor performance in chickens.

Introduction
Free-range system is the most prevalent production system in resource-limited communities with the availability of proper, bio-secure infrastructure limiting the practice of intensive chicken production. With poor bio-security measures, chickens in rural communities are vulnerable to diseases and parasites thereby reducing performance and increasing mortality of the birds. Commercial drugs are unaffordable to a greater portion of rural households and sometimes they have to travel long distances to access the drugs. Communal farmers have resorted to the use of phytotherapy for the treatment of chicken diseases and parasites. The study was conducted to determine the extent of use of Aloe ferox in rural communities for the management of chicken health.

Materials and methods
Fifty-three questionnaires were used to collect data from chicken farmers in the Alfred Nzo Municipality, Eastern Cape, South Africa, identified using snowballing technique. Descriptive statistics were conducted using PROC FREQ of SAS® software version 9.4 to analyze frequencies of socio-demographic data, chicken inventory, the importance of chickens, occurrence and control of diseases and parasites. The Chi-square test (SAS Institute, 2018) was used to test the degree of association among demography, the occurrence and control of diseases and parasites and use of A. ferox in chicken production.

Results
Females constituted 87% of the respondents where 35% were between 56–70 years, and most (89%) relied on social grants. More than 80% had basic education up to the primary level. The average flock size was 3.4 with indigenous breeds being popular (100%) while 15% were broilers. Households (96%) ranked the rearing of chickens for both meat and eggs to be of high priority. The biggest challenge was chicken diseases and parasites (85%) and according to the signs described, the diseases and conditions were Newcastle, Anaemia, respiratory distress, external parasites and worm infestation. Traditional remedies were mostly used (54%) to address chicken health issues with 96% using Aloe ferox prepared by crushing a leaf and mixing it with water. Aloe ferox had no side effects and residual effects on chickens. Choice of medicine (traditional or conventional) was influenced ($P < 0.05$) by the level of education and income.

Conclusions
Chickens played important socio-economic roles by contributing to gender equality and food security as they are mainly kept by women for the provision of meat and eggs although there were health challenges associated with rearing chickens. As such, Aloe ferox was widely used to control poultry ailments and was motivated by farmer's level of education and income.

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038

Use of Ethno-veterinary medicine among poultry farmers in Kogi State, Nigeria

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Application
In view of the recent focus on natural products as alternatives to synthetic drugs in the prevention and treatment of poultry diseases, this research will broaden the knowledge of farmers in the area of herbs and natural products that may be used as alternative to synthetic drugs.

Introduction
Synthetic drugs have been used widely to prevent and treat poultry diseases, and to improve meat and egg production. However, many countries tend to minimize the use of synthetic drugs in poultry because of their residual effects on both animals and humans. Also, cost and availability constraint the access of rural farmers in the sub-Saharan Africa to the synthetic drugs hence this study was carried out to evaluate the use of natural herbs for the treatment of poultry diseases among poultry farmers in Kogi State, Nigeria.

Materials and methods
Data were randomly collected from 100 poultry farmers in the study area through well-structured questionnaires and oral interview. Data were analyzed using descriptive statistics and logistic regression.

Results
Socio-economic characteristics showed that the modal age of the farmers was 30–40 years, with a mean age of 39 years. Majority (90%) of the farmers acquired formal education and about 50% of the farmers had 1–10 years farming experience. Most of the poultry farmers use

natural herbs such as bitter leaf, Scent leaf and Moringa mostly for coccidiosis (93%), fowl cholera (88%), Newcastle disease (80%), fowl pox (76%), infectious bursal disease (64%) and chronic respiratory disease (51%). The regression analysis indicate that age ($r = 0.033$), poultry farming experience ($r = 0.051$), flock size ($r = -0.040$) and access to veterinary services ($r = -0.009$) were significant in determining the use of natural herbs at 5% level of probability.

Conclusions
Majority of the poultry farmers in the study area use herbs and other natural products to treat common poultry diseases. The farmers' perception also revealed that the use of local methods in managing poultry diseases is indeed effective and reliable.

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039

Differential growth rate of three broiler breeder chicks raised to puberty under the conventional open-sided housing in a tropical environment

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Application
The parent stock breeders are always interested in a well-adapted strain to local conditions, capable of producing quality hatching eggs based on their inherent potential and have been so developed to enhance the availability of day-old chicks at an affordable price for profit maximization. This study provided insights into the performance of different strains of broiler breeder chicks raised to puberty under tropical conventional housing such that farmers can make the right decision regarding broiler breeder strains.

Introduction
The broiler breeder paradox coupled with environmental challenges is of utmost concern, especially to broiler breeders in tropical regions. Thus, developing suitable strains of broiler chickens for the tropical environment has become a growing research interest in the past two decades. However, data are scarce on the comparative performance of the birds in the tropics. This study was conducted to determine and compare the growth rate of three commonly raised broiler breeder strains: Ross (RS), Arbor Acres (AA) and Marshall (MS) under Nigerian conditions.

Materials and methods
Two hundred and forty day-old female broiler breeder chicks (80/strain), having four replicates of 20 birds each. The birds were raised in an open-sided poultry house until puberty in line with the guides. Liveweight (LW), weight gain (WG), feed intake (FI), feed conversion ratio (FCR) and percentage mortality (%MORT) was taken weekly. Early weekly hen-day per strain from oviposition was monitored. The observed data were compared with the expected from the breeders' guides. All data were subjected to GLM analysis using SAS statistical package (SAS, Version 8.2, SAS Institute, and Cary, NC) to determine the effect of strain on growth and early laying performance. $P \leq 0.05$ was considered statistically significant in all the analyses. The significance of the means was separated using Tukey's HSD test.

Results
Results showed that average LW, WG and FI were influenced ($P < 0.05$) by the strain, but average FCR and %mortality were not. Marshall showed significantly higher ($P < 0.05$) LW than the other two strains. LW was generally highest in MS from the second week of growth until the end of the trial. Weight gain was affected throughout the trial. The feed intake increased steadily in all the strains in the first nine weeks. After that, it was stabilized from weeks 10–17; 9–16 and 11–17 of age in MS, RS and AA, respectively. MS showed the best FCR from the second to fourth week of age. Despite the higher LW recorded in MS throughout the study, the strain still ranked best on average hen-day during the early laying period. The observed liveweight of Ross and Arbor Acres in this study were similar to those reported by the breeder companies except for Marshall.

Conclusions
The three strains have great potential to perform optimally in the tropics, especially MS which had the highest potential to perform better reproductively than the other two strains under Nigerian tropical conditions if the liveweight could be modified.

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040

Standardization of fresh cow milk with sodium citrate buffer for turkey semen preservation

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Application
This is research will be beneficial for accelerating genetic improvement in turkey for poultry breeding industry by effectively using outstanding Tom semen. It also reduce cost of rearing Breeder toms. And allow effective transfer of turkey germplasm for cross breeding.

Introduction
The low fertility of diluted tom semen and inability to successfully preserved turkey semen for short periods even at cold temperature has prompted standardization of some potential extender agents used for the dilution and preservation of other farm animal species semen for liquid preservation of turkey semen. This study was designed to standardize fresh cow milk (FCM) for liquid preservation of tom semen.

Materials and methods
1 ltr of fresh cow milk was collected from the Fulani cattle kraal and heated for 5mins. Fresh cow milk extenders were prepared using different concentration of Fresh cow milk viz: 25%, 50%, 75% and 100. Five toms were ejaculated individually and pooled. The pooled semen was divided into five portions making five treatments and extenders were added to it in ratio 1:3 (semen: extender). Experimental design used was complete randomized design. Three different trials were conducted. Microscopic semen parameters such as motility, viability membrane integrity were examined and recorded for freshly extended semen and semen preserved for 4 hrs, 24 h and 48 h at 4–8 °C.

Results
The result showed that no significant different ($p > 0.05$) was observed in 0h. However, from 4 to 48 h of preservation, tom semen preserved with 25%, 50% and 75% Fresh cow milk were statistically similar ($P > 0.05$) but,significantly different ($p < 0.05$) in motility and membrane integrity from un-diluted semen and 100% Fresh cow milk. However, 75% Fresh cow milk has the highest motility values of 75.00%, 60.00% and 36.67% and membrane integrity values of 60.67%, 56.33% and 42.00% at 4 h, 24 h and 48 h respectively. At 0 h and 24 h, tom semen preserved with 50% Fresh cow milk extender has highest non-significant percentage live sperm value of 89.67% and 80.00% respectively compare to tom semen preserved in 25% and 75% Fresh cow milk extender. While at 4 h and 48 h, no significant different was observed among the treatments.

Conclusions
It is therefore concluded that 75% Fresh cow milk supplemented with 25% sodium citrate buffer preserved tom semen for 48h better than other combinations.

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041

Identification of a suitable buffer with coconut-water for turkey semen preservation

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Application
This research is useful for poultry breeding industries for accelerating genetic gain in turkey species and reduce cost of rearing toms.

Introduction
Buffers remain one of the essential components of a reliable extender. For better and prolong in-vitro activities of turkey sperm cells, identifying the most effective buffer for the preparation of extender is very important. The buffering capacity of three different salts (Tris, Sodium citrate and sodium phosphate) were evaluated for preservation of turkey semen for 48 h.

Materials and methods
A total of five toms were used for the experiment. The toms were ejaculated and pooled. The pooled semen was divided into four equal parts. The coconut-water was collected, divided into three and supplemented with three different buffers; tris, sodium citrate and sodium

phosphate in the ratio of 1:3 (semen:extender). The undiluted and diluted semen were evaluated immediately after dilution and preserved for 48 h. During the periods of preservation, the preserved semen sampleswere further evaluated at 4 h, 24 h and 48 h.

Results
The result revealed that tris coconut-water extender has the lowest pH of 7.25 among the three extenders prepared, while Sodium citrate coconut-water and sodium phosphate coconut-water has the same and higher pH of 7.3. No significant ($p < 0.05$) different was observed in motility of freshly diluted semen among the treatments. At 4 h, tom semen diluted with sodium citrate coconut-water has the highest motility value of 71.67%, although was not significantly ($P > 0.05$) different from tris coconut-water. At 24 h, tom semen diluted with tris and sodium citrate coconut-water has the same significantly ($P > 0.05$) higher motility value of 48.33% compared to undiluted semen and sodium phosphate coconut-water. At 48 h, tris coconut-water has highest significant ($P < 0.05$) motility value of 40.00% compare to other treatments. No significant different ($p > 0.05$) was observed on viability at 0 h, 24 h and 48 h, although tris coconut-water has the highest values in those respective preservation periods. However, at 4 h of preservation significant different ($p < 0.05$) was observed among the treatments with tris and sodium citrate coconut-water having significant higher values of 92.00 and 91.00. At 0 h, sodium citrate coconut-water has the highest sperm membrane integrity of 86.67% but was not significantly different ($p > 0.05$) from tris coconut-water (86.33%) and neat-semen (84.67%). At 4 h and 24 h, tom semen preserved with sodium citrate coconut-water likewise has the highest sperm membrane integrity value of 69.00% and 50.33% respectively, but was not significantly different from tom semen preserved with tris coconut-water (61.67% and 49.00%).

Conclusions
The present study revealed that diluents containing coconut water with sodium citrate/tris as a buffer yielded relatively high sperm survivability as was evident with the motility, viability and membrane integrity results obtained.

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042 (Invited Speaker)

Ensuring safe and effective feed additives for animals: Risk assessment function of the reconstituted Advisory Committee on Animal Feedingstuffs (ACAF)

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The Food Standards Agency (FSA) FSA has a major role in implementing the legislation relating to animal feed in England, Wales and Northern Ireland. The Advisory Committee on Animal Feedingstuffs (ACAF) performs part of the risk assessment for applications for authorisations (broadly) for feed additives. Previously this role had been carried out by the Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) of the European Food Safety Authority (EFSA). In the words of FSA, ‘‘ACAF advises on the safety and use of animal feeds and feeding practices, with particular emphasis on protecting human health, and with reference to new technical developments”. This presentation will provide an overview of the function of ACAF, highlighting some areas of relevance to potential applicants for authorisation. It will address the legislative framework post Brexit; the purpose of the authorisation process (identity, safety, efficacy); ACAF processes (renewals, re-authorisations, new authorisations, modified use authorisations); ACAF composition and activities; common problem areas in applications; some of the challenges arising from interpretation of EU legacy guidance documents.

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043 (Invited Speaker)

What do we need to do to deliver consumer demand?: A retail perspective

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Dr Birnie's presentation is focused on existing and emerging consumer demand, considering the main factors which drive the retail market as well as key retailers in the UK and abroad. National and International factors are considered, with the impact of growing population, economic affluence and short term economic shocks balanced against the need for reduced environmental impact and improved biodiversity.
The presentation will also consider the implications for animal science, including the need for food quality, increased productivity, increased production and reduced waste, as well as price competitiveness. The collection, use and flow of data are discussed in some detail, including what is required to specifically meet the needs of retailers and consumers.
The paper concludes by highlighting the need for research into practice and technology which addresses the following:

1) Accurate and simple on-farm data collection which enables
   a. Real-time assurance around animal welfare
   b. Independent assurance around environmental and biodiversity performance
   c. Accurate, simple comparison of animal performance and productivity with direct feedback on required improvement
   d. The identification of research needs
2) The development of practical technologies or systems which
   a. Take a holistic view of farm practice, considering whole farm impact, not just impact on specific areas
   b. Enable rapid and accurate measurement of biodiversity
   c. Enable a reduction in methane and other GHGs
   d. Enable quality guarantees to be provided
   e. Enable highly productive agriculture with improved environmental performance

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044 (Invited Speaker)

Dietary transition from animal to plant-derived foods: Are there risks to health?

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In Western societies there is a rising interest in the replacement of animal-derived protein (ADP) sources with those from plants. This is based primarily on the notions that plant proteins are healthier and less impactful on the environment than ADP. Both positions are flawed, in good part because there are over-simplistic. A key issue is that all ADPs are not the same, being supplied by milk/dairy products, meat, fish, and eggs each of which varies in nutritional composition and the association with chronic diseases. For example, dairy foods are not associated with increased cardiovascular disease risk despite being major dietary sources of saturated fats (Givens, 2022) and the cancer risk linked to red meat is about twice as great for processed meat than red meat (WCRF/ACIR, 2018). Another often ignored issue is that ADPs are provided by foods that are also generally richer in a range of micronutrients than those from plants. This is a major concern because in the UK, since recent reductions in milk consumption have led to sub-optimal (less than the lower reference nutrient intake) intakes of calcium and magnesium by teenage females in particular (Roberts et al., 2018), at a time when bone growth is at its maximum and of iodine (Roberts et al., 2018) especially during pregnancy, needed to ensure that supply/production of thyroid hormones to the foetus is adequate. Low intake of calcium and magnesium is a particular concern since many people are also of sub-optimal vitamin D status (Cashman et al., 2016). This may already have had serious consequences in terms of bone development which may not be apparent until later life with recent meta-analyses showing that vegetarian and vegan diets are associated with increased risk of bone weakness and breakage (Iguacel et al., 2018; Tong et al., 2020). It is also likely that the dietary transition from ASP to those from plants is not universally valuable since globally, some two billion individuals suffer from micronutrient deficiencies (Adesogan et al., 2020) leading to multiple health impacts including impaired cognitive development in children which has an effect throughout adult life. It is of course true that many people live healthily whilst consuming vegetarian and vegan diets, but this involves a good understanding of the risks and highly focused dietary management which is often associated with a generally healthy lifestyle.

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045 (Not Present)

Stakeholders' perceptions of the use of Digital Livestock Technologies (DLTs) to automate animal welfare assessments

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Application
This work has commercial, economic and societal relevance since it aims to inform the use of digital livestock technologies in the context of quality assurance scheme based on stakeholders' perceptions. This work is relevant for consumers, farmers, industrials, and governmental bodies.

Introduction
Animal welfare standards are used within the food industry (e.g., assurance schemes) to demonstrate efforts in reaching higher welfare on farms. To verify compliance with those standards, inspectors conduct regular animal welfare assessments during on-farm visits. Conducting these welfare assessments, which often use resource- and outcome-based measures, can be time-consuming and prone to human bias. The emergence of Digital Livestock Technologies (DLTs), such as Precision Livestock Farming (PLF) technologies, offer new ways of monitoring farm animal welfare and can alleviate some of the challenges of welfare assessments by collecting data automatically and continuously. Whilst the use of DLTs to automate welfare assessments is promising, less attention has been paid to stakeholders' perceptions and the perceived challenges that could prevent the successful implementation of DLTs in this context. Implementing DLTs can be costly for farmers, and a lack of validation and reliability of DLTs can impact their trust in the system. In addition, some outcome-based measures, such as those related to positive animal welfare, can be difficult to automate. This study aims to address this gap using a case study during which a camera system designed to monitor lameness and Body Condition Scores in dairy cattle was developed and tested on 9 pilot farms in the context of a quality scheme.

Materials and methods
The work is based on a case study during which a camera system designed to monitor lameness and Body Condition Scores in dairy cattle, that was developed and tested on 9 pilot farms in the context of a quality scheme. Semi-structured, in-depth interviews were conducted with relevant stakeholders (N = 12, including farmers, quality scheme workers and technology developers).

Results
Findings suggest that there are important perceived benefits of automating data collection; from building consumer trust by increasing transparency to improved efficiency and saving costs and labour from manual assessments. There is also a potential for greater consistency and fairness by removing possible biases and levelling the playing field between farms. However, there were also potential risks identified, including those related to data ownership and costs. Concerns were also raised about the possibility of penalising some farmers over others (e.g., use of automated data collection vs manual, or if the systems fail).

Conclusions
Automating data collection in the context of quality schemes can have important benefits, however, possible impacts on farmers and animal welfare must be considered. To mitigate these risks, better clarity should be given to farmers in relation to data ownership and evidence provided in terms of technical performance and accuracy, and measures must be undertaken to increase trust (e.g., by combining automation with third-party scoring).

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046

Use of existing precision livestock farming tools to identify positive welfare in dairy cattle

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Application
Precision livestock farming technologies already in use for management purposes (oestrus/illness detection) may be used to improve understanding of animal welfare in an automated way, inform farmers on herd health/dynamics and provide a verifiable, non-biased indicator of positive welfare.

Introduction
UK consumers have an interest in dairy cattle welfare, with 93% of respondents to a 2009 study (Ellis et al., 2009) confirming a willingness to pay more for good dairy welfare practices. Providing dairy cows pasture access allows increased opportunity for expression of natural behaviours, may improve health, and many consumers consider it a clear indicator of good welfare and ‘‘happy cows”. This work looked to compare automatically collected sensor data with manually collected behavioural data to explore positive animal welfare on UK dairy farms.

Materials and methods
Qualitative Behaviour Assessment (QBA) (Andreasen et al., 2013) was carried out twice on four farms, at pasture and during housing, and 20 QBA metrics examined in relation to animal-mounted sensor outputs. On each farm, for each location, 20 animals were randomly scored by one staff member, giving 160 data points (80 housed and 80 pasture). Sensor data from leg-mounted accelerometers were acquired during housing and pasture for lying times and step count. Principal components analysis (PCA) was used to analyse QBA data in R using parallel analysis.

Results
Behavioural assessment showed animals at pasture displayed more positive behaviours. Positive PC1 scores were observed in 67.5% of pasture cows, where PC1 score refers to mood and runs negative to positive. In comparison, PC1 for housed cows showed 61% of animals had a negative behavioural score. Sensor data, particularly step count and lying time, differed with cattle location - housed or pasture – and correlated with QBA data. For example, step count was positively correlated with ‘‘happiness” (p = <0.001, r = 0.4), PC1 score (p = <0.001, r = 0.3) and others. There was significantly greater ‘‘clustering” of lying times at pasture (p = 0.004), with cows lying for similar times compared to housed cows. Clustering at pasture was attributed to the potential for cows to lie down at the same time, i.e., lying synchrony. As a result of increased lying space at pasture, cows have the ability to exhibit similar behaviours at the same time, which can be limited indoors by housing and management practices. Behavioural synchrony - e.g., lying and feeding synchrony - has been shown to be a positive welfare indicator in cattle (Fregonesi and Leaver, 2002; Napolitano et al., 2009). A smaller spread of QBA scores was noted at pasture, also suggesting higher levels of synchrony, with more animals exhibiting similar levels of behaviours.

Conclusions
This work suggests that it is possible to use automatically collected sensor data to understand positive welfare in dairy cattle. The potential for an automated link between existing farm management sensor data and positive cattle welfare is the subject of continuing work (https://www.digitaldairychain.co.uk).

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047 (Not Present)

Worldviews, values and perspectives towards the future of the livestock sector

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Application
This study demonstrates the importance of worldviews and values in influencing livestock future perspectives. Understanding the processes that lead to the formulation of perspectives will be paramount in developing solutions for sustainable livestock futures.

Introduction
The livestock sector is under increasing scrutiny due to numerous sustainability challenges related to both the production and consumption of livestock products. However, political and market barriers and conflicting worldviews and values across the environmental, socio-economic and political domains have led to considerable sector inertia. This paper presents the results of a mixed methods approach, combining survey and interview data, to explore the influence of environmental worldviews, values and demographic factors on perspectives towards the future of the livestock sector.

Materials and methods
The survey targeted livestock sector representatives and explored participant reactions towards different livestock future problem statements and scenarios, and participant's environmental worldviews and values utilising the New Ecological Paradigm scale (NEP) (Dunlap et al., 2000) and relational values (Chan et al., 2016). A series of multivariate ordinary least squares regressions were conducted on the survey data to explore the effect of NEP on the level of agreeance with each problem/scenario and the effect when controlling for relational values, gender, age, years in sector and occupation. Ten follow-up interviews were conducted to explore the survey themes in more detail. Participants were selected to represent a range of worldviews, values and demographics.

Results
Based on a sample of livestock representatives (n = 307), respondents with higher pro-environmental and ecocentric worldviews and values were significantly more likely to consider the problem being that there is too much inequality and greed in current systems, favouring more behaviour-oriented solutions like meat reduction or smaller scale, local production and artificial meat solutions ($\alpha < 0.01$). In contrast, those with lower pro-environmental and higher technocentric worldviews and values were more likely to think that there is not enough food in current systems ($\alpha < 0.05$), that we can continue to increase global meat consumption and instead invest in technological solutions to improve the efficiency of meat production ($\alpha < 0.01$). Demographic variation and qualitative data emphasise the need to recognise cultural and geographic nuance in narratives.

Conclusions
The results of this study improve our understanding of the processes that lead to the formulation of perspectives, enabling the development of more holistic solutions that acknowledge all voices in an increasingly polarised debate.

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048

Welfare assessment of Skopelos goats under intensive and extensive farming systems

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Application
Assessment of goat welfare in intensive and extensive farming systems enables targeted modifications of husbandry practices and herd health management protocols. In practice, having objective indicators facilitates adjustments to address societal demands for welfare-friendly livestock production.

Introduction
The notion that extensive goat farming systems favour animal welfare compared to intensive ones is subject of debate due to lack of relative scientific studies. Hence, the objective of this prospective study was to use animal-based indicators to assess health and welfare of the same breed of goats raised either on intensive or extensive systems.

Materials and methods
The study involved purebred Skopelos goats with the same genetic background being offsprings from an extensively raised flock located in Skopelos island (Farm A). Farm B, was an intensive farm located in Paiania, Attiki and raised goats that were purchased from Farm A, 3 years prior to the present study. One hundred thirty and 100 goats were randomly selected in Farm A and Farm B, respectively. After weaning, each individual goat was subjected to thorough clinical examination for the evaluation of the occurrence of eye disorders, lameness, arthritis, overgrown hooves, udder health problems, head and body lesions, faecal soiling, poor hair quality, abscesses, and swollen lymph nodes; milk yield was also recorded. In total, four recordings were carried out on a bimonthly basis. Data analysis was done with IBM SPSS v26. Prevalence of health indicators was calculated at farm level for each recording. A binary mixed model was used to assess the impact of production system on recorded welfare indicators. Age, farm, stage of milking period, and milk yield were used as fixed effects in the model. Statistical significance was set at the 0.05 level.

Results
A higher prevalence of lameness (0.0–3.9% over 0.0–1.0%, $p < 0.05$), overgrown hooves (1.0–21.2% over 0.0–2.3%, $p < 0.001$), and gingivitis (1.0–5.7% over 0.0–1.7%, $p < 0.001$) were observed in Farm B compared to Farm A. Also, in Farm B, goats had a higher prevalence of swollen submandibular lymph nodes compared to Farm A (2.8–2.9% and 5.8–8.7% over 0.0–0.8% and 0.8–1.7%, $p < 0.05$ and $p < 0.01$ in the right and left submandibular, respectively). Goats in farm A had, higher anaemia prevalence (1.9–11.5% over 5.3–37.0%, $p < 0.001$), poorer hair quality (8.7–31.0% over 16.5–47.0%, $p < 0.01$), and higher prevalence of swollen prefemoral (0.0–1.0% and 7.6–15.7%, over 0–1.0% and 9.9–10.6%, in the right and left prefemoral, respectively, $p < 0.01$) and prescapular (2.9–6.6% over 6.8–13.4%, $p < 0.01$) lymph nodes.

Conclusions
Feet-related problems were dominant in the intensive system, whereas, poor nutrition, parasitism, and caseous lymphadenitis prevailed in the extensive one, indicating a demand for further research and benchmarking activities to support case-specific herd health management interventions in both systems.

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049

Architectural design to mitigate indoor heat stress in a dairy cattle house under a heatwave event

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Application
The architectural design of the livestock buildings and their day-to-day operation have a profound influence on the indoor heat stress of animals, but this is much under-researched. This study employed state-of-the-art building thermal modelling tool to assess the impacts of different architectural design strategies on mitigating the indoor heat stress risk and identify the most effective design interventions.

Introduction
Dairy cattle are susceptible to temperature changes, especially the rapid rise of temperature or long periods of extreme heat. Therefore, strategies to alleviate the heat stress of dairy cattle during heatwave becomes a crucial issue in dairy cattle industry for the good welfare of the cattle. The objectives of the study are: 1) to understand the indoor heat stress in a dairy cattle house during a heatwave event in the UK; 2) to assess the impact of different building design interventions to reduce overheating risk in such dairy cattle house.

Materials and methods
Indoor heat stress measurement (THI) has been conducted during the heatwave period of 2018 in both barn and milking areas. Building thermal modelling has been carried out to assess the impacts of different architectural design interventions on the overheating risk in both regions in the cattle house, after the model is validated using the measurement data.

Results
Our measurement results found both barn and milking parlour were overheated during the heatwave event and milking parlour was overheated for more than 90% of the time (with THI higher than 68). We also compared three types of architectural design mitigation strategies, i.e., white roof, natural ventilation and exhaust fan. The white roof could reduce the indoor temperature maxima by 4K and overheating degree hours by 11%, but all the mitigation strategies combined could reduce overheating risk by 89%, therefore significantly improve the welfare of the dairy cattle.

Conclusions
Architectural design could reduce indoor overheating risk in dairy cattle house and therefore improve the welfare of the dairy cattle during heatwave period.

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050

Bovine respiratory disease changes feeding behaviours in pre-weaned artificially reared calves

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Application
An understanding of how disease affects behaviour is essential for the development of behaviour-based disease detection tools. Earlier detection improves outcomes and reduces antimicrobial use.

Introduction
Respiratory disease is common in pre-weaned artificially reared calves and represents significant economic loss. Calf behaviour has been shown to change early in the disease process and thus has potential as an early disease detection tool. The objective of this study was to determine differences in behaviour between healthy calves and those with bovine respiratory disease.

Materials and methods
114 calves were observed from entrance into a straw-bedded group pen at approximately eight days of age until 39 days of age. Calves were fed a restricted daily milk allowance of seven litres of milk replacer (150 g/Litre) through an automatic milk feeder. Calves had ad-libitum access to calf starter and straw in racks. Calves were Wisconsin health scored daily and behaviours were continually monitored using a tri-axial accelerometer and the automatic milk feeder. For statistical analysis, diseased calves with a peak Wisconsin score $\geq$5 were paired with a healthy calf in the same group, of the same sex, within seven days of age and within ten kilograms of live weight. Healthy calves had no treatment events, a rectal temperature of <39.4 °C and a Wisconsin score of $\leq$3 for five days prior to and after the peak disease day. Eighteen pairs were analysed for the feeding behaviours and fourteen for activity parameters. The activity parameters tested were daily lying time, daily standing time, daily lying bouts, daily standing bouts, mean lying bout length, mean standing bout length, total daily activity and mean activity/standing bout. The feeding behaviours tested included daily milk intake, total time at milk, total milk visits, mean milk visit length, mean milk per feed and mean milk drinking speed.
Generalized linear mixed modelling was used to assess the effect of disease and day versus peak disease with group included as a random effect. Estimated marginal means with pairwise comparisons were used.

Results
Mean milk visit length was greater in diseased calves compared to healthy calves on day 0 and day 3 relative to the day of peak disease (p < 0.05). In addition, the total time at the milk feeder was greater in diseased calves compared to their healthy counterparts (p < 0.05) on day 3 relative to peak disease. No other parameters showed significant changes with disease on any of the days tested.

Conclusions
In limit fed calves, both the mean time per visit to the milk feeder and the total time at milk are increased. The changes in behaviour seen with disease is different in limit fed calves to those seen previously in ad-libitum fed calves. This has implications for development of automated tools for disease detection.

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051

The potential for milk markers as indicators of health disorders in transition dairy cows

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Application
Determine how extramammary conditions (EMC) influence inflammatory markers in milk during early lactation as potential disease indicators.

Introduction
Inflammatory markers in blood are disease indicators. Studies investigating inflammatory markers in milk focus on mastitis. Little is known about how EMC influence inflammatory markers in milk during early lactation. Measuring such markers in milk is promising as it is less invasive and labour intensive than blood sampling. We characterised the profiles of haptoglobin (Hp; inflammatory protein) and substance P (neuropeptide involved in immunomodulation) in milk during 3 weeks postcalving in clinically-healthy dairy cows and those experiencing an intramammary condition (IMC) or EMC postcalving.

Materials and methods
Multiparous Holstein-Friesian dairy cows (n = 111) from a commercial dairy herd were enrolled provided they were not visibly sick or lame 3 weeks precalving. Health and milk yield and somatic cell count data were retrieved from the on-farm database. Composite milk samples were collected on days 0–4, 7, 14, and 21 relative to calving and Hp and substance P concentrations determined using ELISA. Retrospectively, based on their health status within 5 weeks postcalving, cows were assigned to 3 groups: Control (no clinical ECM, or subclinical or clinical IMC; n = 76), Extra ($\geq$1 ECM; n = 18), or Intra ($\geq$1 subclinical or clinical IMC; n = 15 and 2, respectively). Differences in milk yield and markers between the 3 groups and across weeks and days, respectively, were investigated using a repeated-measures ANOVA (PROC MIXED, SAS).

Results
Extra cows yielded less milk (mean ± SEM; 33.9 ± 1.42 kg/d; $P < 0.01$) than Intra cows (38.1 ± 1.43 kg/d), which in turn, tended ($P = 0.10$) to yield less milk than Control cows (39.5 ± 0.36 kg/d). Mean Hp and substance P concentrations were associated with day (both $P < 0.001$) and were greater on day 1 postcalving (0.53 ± 0.02 μg/ml and 70.1 ± 4.16 pg/ml, respectively) compared with all other days (all $P < 0.05$). There were no interactive health status and day associations for both milk markers (both $P > 0.68$), and health status was not associated with milk Hp (range = 0.28–0.32 μg/ml; $P = 0.29$) and substance P (range = 42.8–45.9 pg/ml; $P = 0.67$).

Conclusions
Milk Hp and substance P were not influenced by EMC. Milk Hp concentrations were elevated 1 day postcalving and were commensurate with concentrations reported in healthy cows and lower than concentrations reported in clinically mastitic cows. Milk Hp may have potential as a mastitic marker immediately postcalving.

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052

Association of rumen fill and motility with subclinical ketosis in post-partum Holstein cows

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Application
Timely recognition of cows with potentially impaired future reproductive performance.

Introduction
Rumen fill and motility, expressed as Rumen Fill Score (RFS) and Rumen Contraction Score (RCS), as well as subclinical ketosis (SCK), are negatively associated with reproductive performance (Valergakis et al., 2021, 2022; Walsh et al., 2007). Our objective was to explore the prevalence of SCK associated with post-partum (pp) RFS and RCS, aiming to evaluate them as means of early warning.

Materials and methods
Two independent data-sets with 237 cows from 6 farms (DATA1, day 7pp) and 726 cows from 9 farms (DATA2, day 8pp) were used. Rumen fill was scored in a 5-point scale, based on left paralumbar fossa depth [1: very low dry matter intake (DMI), RFS-1 (n = 11/151 for the 2 data-sets); 2: low DMI, RFS-2 (n = 98/408); 3, 4 and 5: adequate, high and very high DMI, RFS-3 (n = 128/167)]; RCS was assessed with auscultation at the left paralumbar fossa, once, 2 hours after the morning feeding and was considered a binary trait [RCS-1: 0-1 contraction/2 min (n = 39/94), RCS-2: 2 or more contractions/2 min (n = 198/632)]. At the same time-points, serum b-hydroxybutyrate (BHB) concentrations were determined. Three different thresholds for SCK were considered: 1,000 (a), 1,100 (b) and 1,200 μmol/L (c). Prevalence of SCK was calculated as the number of positive cases per number of cows involved (total and per rumen-trait category); statistically significant differences among rumen-trait categories were assessed with chi-square test.

Results
Regarding DATA1, overall prevalence of SCK was 9.7%, 8.9% and 8.0% for (a), (b) and (c), respectively. For RFS-1, RFS-2 and RFS-3, threshold-based prevalence of SCK was: 27.3–12.2–6.3% (a), 27.3–10.2–6.3% (b) and 27.3–9.2–5.5% (c), respectively. For RCS-1 and RCS-2, SCK prevalence was: 25.6–6.6% (a), 25.6–5.6% (b) and 20.5–5.6% (c), respectively. Differences between RFS-1/RFS-3 and RCS-1/RCS-2 were always statistically significant ($P < 0.05$). Regarding DATA2, overall prevalence of SCK was 14.3%, 12.0% and 10.7% for (a), (b) and (c), respectively. For RFS-1, RFS-2 and RFS-3, threshold-based prevalence of SCK was: 23.2–15.4–3.6% (a), 21.4–12.5–1.8% (b) and 20.5–10.8–1.8% (c), respectively. For RCS-1 and RCS-2, SCK prevalence was: 27.7–12.3% (a), 25.3–10.0% (b) and 23.4–8.9% (c), respectively. All differences were statistically significant ($P < 0.05$).

Conclusions
Cows with reduced rumen fill and motility had higher prevalence of SCK. Considering the association with reproductive performance, rumen traits unveil far more cows needing support to maintain reproductive efficiency than SCK.

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053

Steaming up Bunaji Cattle using Maize and Wheat Bran concentrates

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Application
The study was conducted to investigate whether the use of maize bran would be better than using wheat bran when Bunaji breed of cattle are being prepared for gestation. The better concentrate would then be used to formulate a total mixed ration for a future study.

Introduction
Steaming up is claimed to increase milk production (Pradhan et al., 2011). Nigeria's potential for milk production is high and the possibility of achieving good quality milk will be enhanced if cows and their condition of management are improved. The objective is to determine the better concentrate in terms of milk quality among the two most demanded concentrates such that dairy farmers become informed. Milk quality and quantity was assessed when the two sources of bran were fed as supplements.

Materials and methods
A total number of twelve (12) cows were used with four (4) cows in each treatment arranged in a completely randomized design. Treatment one (T1) was the control diet and cows were not steamed up. Treatment two (T2) were fed Wheat Bran while animals in treatment three (T3) were fed Maize Bran. The animals selected were at third parity and fed 1kg each, daily, beginning from 30th week of gestation. The feeding lasted for six weeks (±2 days) before expected date of calving, including 2 weeks adjustment period. After calving, the milk samples were collected on 7th day and tested for clot on boiling, acidity, pH and organoleptic properties. Parameters for cow lactation were also measured.

Results
The study discovered that the specific density of the milk varied ($P < 0.01$) between treatments, where T2 recorded a higher value (1.441g/cm^3). Furthermore, a significantly higher ($P < 0.01$) percentage of lactic acid was observed for T1 (0.247%) than T2, which recorded 0.590%. No significant difference in the pH among all treatments was observed. Observed characteristics on clot boiling were all negative (normal) while there was slight variation in flavour test and colour among the treatments. The chemical composition of milk showed the Butter fat for steamed up cows was significantly ($P < 0.01$) greater (5.6 and 6.2% for T2 and T3 respectively) than that of the control diet (3.6%). Birth weight of calves for T2 and T3 (32.2 and 32.6 kg) was also significantly ($P < 0.01$) higher than cows that were not given concentrates, which recorded 28.1kg.

Conclusions
Milk from Cows supplemented with Maize Bran tasted better than milk from Wheat Bran. Though birth weight of calves was similar for T2 and T3, it was slightly higher for T3 when compared with T2. Therefore the use of Maize Bran is encouraged.

Acknowledgments
The work was done with animals from Rugan Alhaji Dauda in Liman Katagum village of Bauchi, Nigeria.

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054

How UK livestock farmers manage their workloads and the demands of farm assurance

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Application
This research contributes to our understanding of barriers to compliance with best practice in animal welfare and livestock disease control. The study also contributes to research on farm-level resilience and change by paying close attention to how labour issues affect farm decisions.

Introduction
The aim was to explore how livestock farmers in the UK are managing their workloads and the need to comply with sustainability standards, at a time when they are constrained by financial pressures and labour shortages. Whereas the labour implications of agri-environment schemes have been expertly studied, there has been less research on private-sector farm assurance schemes.

Materials and methods
A mixed-methods approach was used, combining: analysis of assurance scheme documents; data from the Farm Business Survey; a postal survey of 230 farms; and telephone interviews with 34 farmers, focusing on businesses with cattle or sheep in Herefordshire, Shropshire and Wiltshire. Theories of farm resilience were used to conceptualise how farms accommodate labour pressures (Atkinson, 1984; Sutherland et al., 2012; Darnhofer, 2021).

Results
The study identified an increase over time in operational rules that farms must comply with to qualify for grant payments, remain certified and access markets. Livestock farms also face demands for increasingly sophisticated measures of record-keeping, planning and monitoring, requiring IT literacy.
In particular, the study documents the growth in external requirements concerning animal health and welfare. Standards are being driven by supermarkets and dairy companies, private livestock buyers, and government and industry initiatives. To date the greatest burden has fallen on dairy farms, but the requirements for beef and lamb producers are growing.
Following observations of Sibley (2006) and Escobar and Demeritt (2016), this study found that farmers need to agree with the purpose of what they are being asked to do by external actors if they are to stick with it. The financial and labour costs of compliance were prompting some sheep farmers in the study to consider dropping out of the Red Tractor scheme.
The research found that most livestock farms have the capacity to stretch their labour force to accommodate additional demands. Livestock farms are also adept at postponing non-urgent tasks and adjusting their production systems. However, some farms' labour systems were under strain.

Conclusions
The study finds that if livestock farms are to fully implement new practices in animal health and welfare and avoid becoming overstretched, many livestock farms will need to find ways to afford and access additional help. Public- and private-sector actors that set sustainability and ethical standards in UK agriculture could also streamline farm assurance and farm inspections. Industry bodies should continue to encourage collaboration between farms and vets to manage livestock disease, but they must recognise that farmers are not always IT-literate and do not always work in an experimental way.

Acknowledgments
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055

People standings on existing farm animal welfare legislation in major countries and economic blocks around the world

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Application
If the globalized trade of animal products does not find common grounds for standardization, the risk of countries with more advanced farm animal welfare (FAW) legislation to impose trading barriers, increases. Exporting countries may perceive FAW as protectionism. This work may be helpful for stakeholders and policymakers for the development of relevant policies for the global trade of farm animal products.

Introduction
People in the different countries of the world have different views and perceptions regarding animal welfare advances as well as legislation implementations. The globalized trade is facing challenges, with consumers in different countries perceiving FAW differently. The countries known by the acronym BRIC (Brazil, Russia, India, and China) together with the EU and the USA are main international traders of animal products (EU 22%, USA 15%, Brazil 9%, China 4%, India, and Russia 3% each). The BRIC countries accounted for 40% plus of the world population and more than 50% of the world gross agricultural production in 2018 (Ren et al., 2020). This study explored the demand for improved farm animal welfare legislation in Brazil, Russia, India, China, and the USA. Results were discussed in comparison to Western Europe.

Materials and methods
One thousand people were interviewed in each country, rating (1–5 Likert scale) the willingness to support or oppose the introduction of more FAW friendly legislation in their country. The demographics were used as independent variables to model the stated willingness. A multinomial logistic regression was fit to the data ($p < 0.001$), with the parameters "country × gender" ($p < 0.001$), and "country × age" ($p < 0.001$) found significant.

Results
Americans, Russian women, and older Brazilian men are very supportive. The age effect is also felt in India where older people are more supportive. The Chinese, American men, and younger Indians are less supportive. Russian men are the group that oppose the most, followed by younger Brazilians and Indians. Overall and individually in each country, the societal willingness to improve FAW legislation surpasses the opposition.

Conclusions
The laws and their application vary immensely between the BRIC countries, the USA and Europe. The societal willingness to improve farm animal welfare legislation is higher than the opposition and neutrality together, in all countries. The willness to improve FAW legislation is higher in Europe, where more advanced legislation exists already. The demand for improved FAW legislation may impact the international trade of farm animal products if the exporting countries do not meet the standards of the importers.

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056

The potential of grass-clover press cake silage to reduce nitrogen excretion and improve nitrogen use efficiency in lactating dairy cows

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Application
Improve nitrogen use efficiency (NUE; [milk output (kg/d) /N intake (kg/d) * 100]) by replacing 50% of grass silage with grass-clover press cake silage in the diet of late lactation dairy cows.

Introduction
The green biorefinery concept is based on sustainable principles and represents a novel opportunity to use biomass more efficiently (Mandl, 2010; Kamm et al., 2016). Press cake silage obtained from the biorefinery process has potential as feed for ruminants (Savonen et al., 2020). Therefore, the objective of the study was to evaluate the effect of different inclusion rates of grass-clover press cake silage on nitrogen excretion (NEx) and NUE in late lactation dairy cows.

Materials and methods
Six Holstein Friesian cows (185 ± 4.58 DIM) were allocated to one of three dietary treatments in a 3 × 3 Latin Square designed ($n = 6$). Grass-clover press cake silage was obtained by re-ensiling the dry matter remaining after the biorefinery process of grass-clover silage. Dietary treatments were offered ad libitum as a total mixed ration and were as follow: GS (16 kg DM grass-clover silage + 4 kg DM concentrate); PC25 (12 kg DM grass-clover silage + 4 kg DM grass clover press cake silage + 4 kg DM concentrate); PC50 (8 kg DM grass-clover silage + 8 kg DM grass-clover press cake + 4 kg DM concentrate). Each period consisted of 13 d dietary adaptation and 9 d of sampling. Feed intake was estimated daily, milk samples were collected am and pm for 5 d, and NEx was estimated with 24h collection of faeces and urine for 5 consecutive d. Data was analysed using Proc Mixed procedure on SAS (Version 9.4). The model included the fixed effect of treatment and period. Random effect (cow) and repeated measurement (period) were included in the model. Significant differences were considered when $P < 0.05$.

Results
Milk yield for GS, PC25 and PC50 was 19.52 kg/d, 19.14 kg/d and 19.40 kg/d respectively; NEx was 70.95%, 71.16% and 74.97% respectively and NUE was 19.09%, 19.65% and 22.11% respectively. No differences were observed between dietary treatments regarding milk yield (P = 0.75) and NEx (P = 0.20), while animals offered the PC50 treatment had a higher NUE (P < 0.01) compared to the others.

Conclusions
Although treatment did not affect NEx, PC50 has a positive effect on NUE compared to the GS and PC25.

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057

Performance of dairy cows offered high or low digestibility grass silages at a high or low total diet crude protein content

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Application
The response to total diet crude protein was similar with both high and low digestibility silages.

Introduction
Grass silage digestibility drives dry matter intake (DMI) and may also influence protein utilisation by ruminants. While studies conducted over 20 years ago (e.g. Rinne et al., 1999) examined the relationship between silage digestibility and dietary protein levels, silages used had a wide range of crude protein (CP) contents. Within the current study silages with similar CP contents were chosen to reduce confounding effects. The study investigated the impact of grass silage digestibility on the performance of dairy cows offered diets differing in total CP content.

Materials and methods
Thirty-two mid-lactation multiparous Holstein-Friesian dairy cows were used in a two-period (21 day adaption phase, and seven day measurement phase), partially balanced change-over design. Four treatments were organised in a 2 × 2 factorial arrangement, comprising two grass silages differing in D-value ('High D' (74.8%) and 'Low D' (66.8%)) and two total diet CP levels (145 or 175 g/kg DM). The latter were achieved using two iso-energetic concentrates which differed in CP level (173 and 228 g/kg DM). High D and Low D silages had a DM of 280 and 220 g/kg DM and a CP content 120 and 130 g/kg, respectively. Silage and concentrates were offered as a TMR in a 50:50 DM ratio. Data recorded during the final week of each experimental period were analysed using linear mixed model methodology according to the two-period change over experimental design, with constant + treatment as the fixed model, and cow × period as the random model, using REML as the estimation method. All data were analysed using GenStat (21st edition; VSN International).

Results
There were no interactions between silage digestibility and total diet CP, except for milk urea nitrogen (MUN). The High D silage increased DMI (+3.7 kg/day; P < 0.001), milk yield (+0.6.3 kg/day; P < 0.001), milk protein content (+2.2g/kg; P < 0.001) and milk fat plus protein yield (+0.6 kg/day; P < 0.001) and decreased MUN (−36mg/kg; P < 0.001) compared to Low D silage. The High CP diet increased DMI (+1.4 kg/day; P = 0.002), milk yield (+2 kg/day; P < 0.001) and fat plus protein yield (+0.14 kg/day; P = 0.035) compared to the Low CP diet.

Conclusions
The performance of cows offered the High-digestible silage was superior to that of cows offered the Low-digestible silage. High CP level increased performance compared to Low CP level at both levels of silage digestibility.

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058

Impact of grazing silage swards during the winter on quality of first cut silage and dairy cow performance

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Application
Removing autumn grown herbage using grazing sheep improved silage quality and had positive effects on individual cow performance, but lower herbage yields resulted in a lower fat plus protein per hectare.

Introduction
A recent survey of dairy farmers indicated that autumn/winter growth herbage can negatively impact the quality of 1st cut silage produced the following spring. Early closed swards have a higher herbage mass in spring, but contain higher proportions of senescent material compared to later closed swards (Hennessy et al., 2006). The objective of this study was to investigate the effect of leaving grass swards ungrazed following harvest of third cut silage in September, or grazing with sheep in early winter, on the quality of silage produced the following spring and the performance of cows offered these silages.

Materials and methods
The study was repeated during separate growing seasons (Experiment 1 and 2). Following harvest of silage in September, three fields were divided into two blocks each (n = 6 blocks), with one block in each field grazed by sheep during November/December while the other block was left ungrazed. Herbage from both the grazed (G-SIL) and ungrazed (UG-SIL) swards was ensiled the following May and offered to late-lactation Holstein cows in a balanced change-over design feeding trial comprising two 28-d periods (21-d feed adaptation phase and a 7-d measurement phase). Experiments were analysed separately. Animal data recorded during the measurement phase were analysed using linear mixed model methodology according to the two-period change-over experimental design, with constant + treatment as the fixed model, and cow $\times$ period as the random model.

Results
Autumn grazing of swards reduced dry matter (DM) yield by 0.8 and 1.0 t/ha in Experiment 1 and 2, respectively, while improving silage metabolisable energy content by 0.2 and 0.5 MJ/kg DM, respectively. Dry matter intake was unaffected by treatment in Experiment 1, but cows offered G-SIL had a greater milk yield (0.8 kg/day, SED 0.21; $P < 0.001$). Neither milk composition, nor fat plus protein yield were affected by treatment. In Experiment 2, G-SIL cows had greater DM intake (1.5 kg, SED 0.20; $P < 0.001$), while milk yield and milk composition were not significantly different. When calculated on a per hectare basis, total yields of fat plus protein were 128 and 218 kg/ha higher (Experiment 1 and 2, respectively) with the UG-SIL treatment.

Conclusions
Removing autumn growth herbage by grazing sheep had some positive effects on cow performance, but reduced milk fat plus protein yield per hectare.

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059

Short-term consumption of grass silage high in mycotoxins, either with or without added mycophenolic acid or a binder, alters the rumen microbiome without impacting the performance or health of dairy cows

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Application
Feeding grass silage that is high in mycotoxins or the addition of mycophenolic acid does not affect the performance of late lactation cows but alters the rumen microbiome which could alter nutrient use. This could affect the nutritional requirements for a farmer's dairy herd.

Introduction
Grass silage mycotoxins have been suggested to alter the abundance of microbial taxa in the rumen that could affect feed efficiency, performance and health of the cow (Gallo et al., 2015). Previous studies have detected mycophenolic acid (MPA) from *Penicillium* in European grass silage (Schneweis et al., 2000). The objectives of the explorative study were to determine the effect of the short-term consumption of mycotoxin contaminated grass silage on the rumen microbiome, performance and haematology of dairy cows, and evaluate the effect of a mycotoxin binder.

Materials and methods
Five rumen fistulated, multiparous late lactation Holstein-Friesians (255 days in milk ± SEM 26.7) were used in a 5 × 5 Latin square design, with 5 periods each of 23 d duration. A control grass silage was fed for the first 18 d, and during the final 5 d the cows received one of 5 dietary treatments: C: control silage; S: spoiled silage high in mycotoxins; CM: control silage + 5000 μg MPA/kg DM of the total mixed ration (TMR); SM: spoiled silage + 5000 μg MPA/kg DM of the TMR; and SMB: spoiled silage + 5000 μg MPA/kg DM of the TMR + 150 g/head/day Mycosorb® (Alltech UK Ltd.). 5 days were chosen as an exploratory duration of exposure. Intake and milk yield were measured daily during d 19–d 23 of each period and samples of milk, rumen fluid, and plasma collected. Data were analysed by analysis of variance (ANOVA; Genstat VSN International, 2022). Sequence data were parsed using mothur (Schloss et al., 2009) into OTUs at 97% similarity and taxonomic classification of the representative sequences carried out using the SILVA 132 SEED reference database (Yilmaz et al., 2014).

Results
Silage source (control vs spoiled), addition of MPA or binder had no effect ($P > 0.05$) on dry matter intake, milk yield, milk fat or protein concentration, with mean values of 19.5, 22.9 kg/d, 42.4 and 33.9 g/kg respectively. Similarly, there were no treatment effects ($P > 0.05$) on rumen pH, total volatile fatty acid concentration, or plasma haematology parameters. Linear discriminant analysis (LDA) effect size (LEfSe) revealed a lower relative abundance of *Prevotella* ($P = 0.049$, LDA: −2.77), and an unclassified genus of *Bacteriodales* ($P = 0.032$, LDA: 2.72) in the rumen microbiome of cows fed CM compared with C.

Conclusions
Short-term exposure of grass silage that is high or low in mycotoxins, without or with added mycophenolic acid had no effect on measured parameters of cow health and performance. The addition of MPA resulted in changes in the relative abundance of *Prevotella* in the rumen which may alter protein metabolism in the rumen.

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060

The effect of inoculation with either homofermentative alone or mixtures of homofermentative and heterofermentative bacteria on gross energy from Lactic Acid, Acetic Acid and Propane-1,2-diol in maize silage

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Application
Inoculation of forage with heterofermentative bacteria (He) results in greater energy losses from fermentation than with homofermentative bacteria (Ho) with no significant benefit to aerobic stability (AS).

Introduction
Silage inoculants combining Ho+He are used for improving AS of silage. Ho exclusively convert water soluble carbohydrates to lactic acid (LA) during silage fermentation. He convert glucose to LA, acetic acid (AA) and CO_2 and convert LA into AA and Propane-1,2-diol (PD) and CO_2 in a secondary fermentation process. This study examined the effect of changes in fermentation pathways on energy content of biochemicals between samples inoculated with Ho only or Ho+He.

Materials and methods
Preservation jars (Kilner, 2 L) were packed in triplicate with 1350 g chopped maize supplemented with water (control), Ho only (two inoculation levels) or He+Ho (three treatments). Jars were stored at 20 °C for 28 or 90 days post-ensiling (dpe) before being destructively sampled. Water extract was analysed for LA (reverse phase HPLC), AA and PD (Gas Chromatography). Gross energy (GE) values were calculated by multiplying LA, AA or PD concentration by energy density (LA:15.5; AA:14.59; PD:23.45 KJ/g) and presenting the sum in KJ/Kg DM. Aerobic stability was measured using standard methodology (Honig, 1990), where the time (hours) of a known amount of silage to reach 2 °C above ambient temperature after exposure to air was recorded. For each analyte, ANOVA was conducted using Genstat (VSNI, 20th Edition, UK) to test for differences between means at each endpoint. Responses were evaluated for normal distribution, with GE and LA values Log10 transformed prior to analysis. Results are presented as Mean ± se.

Results
At 90 dpe, control and He+Ho treatments contained higher levels of AA (46.85 ± 0.919, 46.34 ± 1.240, 46.77 ± 1.434 and 43.49 ± 0.866 g/Kg DM) than Ho alone (32.90 ± 1.755 and 28.00 ± 2.166 g/Kg DM), ($F_{(5,17)}$ = 31.14, p = <0.001) but lower LA concentrations in control and He +Ho (11.13 ± 0.359, 10.65 ± 0.748, 11.73 ± 0.160, 13.52 ± 3.321 g/Kg DM) than Ho alone (35.44 ± 5.416, 38.97 ± 3.583 g/Kg DM), ($F_{(5,17)}$ = 30.17, p = <0.001). Higher PD concentrations were observed in two of the Ho+He treatments (0.072 ± 0.010 and 0.077 ± 0.007 g/Kg DM), compared with control, (0.058 ± 0.009 g/Kg DM), He treatments, (0.046 ± 0.008 and 0.045 ± 0.005 g/Kg DM) and the remaining He+Ho treatment (0.023 ± 0.001 g/Kg DM), ($F_{(5,17)}$ = 19.50, p = <0.001).
Gross energy (KJ/Kg DM) from AA, LA and PD: Control, (854.0 ± 18.02), HeHo, (840.6 ± 25.97, 839.7 ± 18.9, 862.4 ± 21.33), Ho, (1000.6 ± 24.75, 1018.7 ± 57.07), was different at 90 ($F_{(5,17)}$ = 7.54, p = 0.002) but not 28 dpe. Change in GE between 28-90 dpe were -140.8 ± 23.61, −106.3 ± 61.23, −140.8 ± 17.96, −99.4 ± 33.69, +87.7 ± 31.30, +105.30 ± 69.45 for control, Ho+He and Ho treatments respectively ($F_{(5,17)}$ = 7.57, p = 0.004).
Aerobic stability was similar for all treatments at 28 dpe (174 ± 32.7 h) and 90 dpe where all samples were stable.

Conclusions
Changes in gross energy from LA, AA and PA between 28 and 90 dpe show that utilisation of LA by He during secondary fermentation can result in a loss of GE in silage, which could have an impact on animal performance. Inoculation with Ho+He did not improve AS.

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061

Effect of solid state fermentation using oyster mushroom on the chemical composition of *Brachiaria mulato* II, *Bambusa vulgaris*, Napier grass and Panicum, four Tropical forages, incubated for 60 days

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Application
An Improvement to the quality of matured forages, which are a huge potential energy source for ruminant animals by enhancing their nutrient content and digestibility will improve food security.

Introduction
Feeding all year round is a major predicament that limits ruminant livestock productivity. Forages are abundant and high in nutrient quality during the rainy season and become matured and high in fibre and low in quality at the same time scarce. Biological agents have been used to increase the digestibility of low quality forages (Fazaeli et al., 2006). Fungal treatment could be an approach to improve matured forages for ruminant nutrition (Zadrazil et al., 1996). The potential of *Pleurotus ostreatus* and *Pleurotus eryngii* to reduce indigestible cell wall components have been reported (Singh et al., 1990). Brachiaria mulato II, has been introduced as recent as twelve months ago (November 2021). It was cultivated from the seeds, which were procured from Kenya and growing vibrantly. *Bambusa vulgaris* is an evergreen year round grass that is abundant but not normally fed to ruminant animals in this area. Napier grass and Panicum grow wildly and are normally harvested and used for feeding ruminant animals. The objective of the study was to determine the chemical composition of the four forages harvested at 180 days of regrowth and inoculated with the mycelia of oyster mushroom for sixty days.

Materials and methods
The study was carried out using the completely randomized design (CRD). There were four treatments, which were the four individual forages, with three treatments each. The harvested forages were dried under shade separately for seven days and milled to pass through a sieve size of 2 mm, using Silver Crest (SC-1589) mill. Twenty grams of milled forage was weighed into clean 250 ml conical flasks and 70 ml of distilled water was added and stop cocked with non-absorbent cotton wool. The forage and flask was sterilized by autoclaving at 121 °C and 1.2 kg/cm^2 of pressure for 15 minutes. The flasks were cooled to laboratory temperature of 25–28 °C.
Three 5 mm cut-out oyster mushroom mycelia were aseptically introduced into each sterilized flask, which were then wrapped in aluminium foil and incubated in the laboratory at 25–28 °C and relative humidity of 80% for 60 days and then terminated.
The samples were analysed for DM, CP, CF, Ash and NDF using the standard methods of AOAC (2015) and the methods of Van Soest et al. (1991).
The data obtained from the study was subjected to analysis of variance (ANOVA) using SPSS Version 20. The means were separated using Tukey's pairwise comparison at 5% level of significance.

Results
The results of the study showed that DM, CP, CF and Ash were significantly ($P < 0.05$) different among the treatments. The CP content increased significantly ($P < 0.05$) for all the forages from 82.1, 160.9, 112.7 and 85.4 g/kg DM to 102.9, 168.6, 190.5 and 102.9 g/kg DM. The CF content decreased significantly ($P < 0.05$) for all the forages from 334.2, 246.7, 243.5 and 392.3 g/kg DM to 292.6, 206.5, 188.9 and 272.1 g/kg DM for *Brachiaria mulato* II, *Bambusa vulgaris*, Napier grass and Panicum respectively.

Conclusions
Inoculation of the forages with oyster mushrooms improved the CP content and reduced the CF content thus improving the quality of the matured forages.

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062

UK beef and sheep farmers' barriers to adopting rotational grazing systems

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Application
The results of this work will be used to create a baseline of grazing systems within the UK and allow us to highlight key barriers and enablers to different grazing practices. This will be used to help encourage long-term change to more economically and environmentally sustainable grazing systems.

Introduction
Despite the importance of grassland management in farm economic and environmental performance, little is known about current grassland management practices. Furthermore, it is unknown what farmers' attitudes are to grazing practices that require regular pasture measurement and data input – measures that require additional labour and other costs but can notably improve the efficiency of grass utilisation. This study aims to understand better current grazing management on beef and sheep farms and the barriers to adopting potentially more productive and efficient (e.g., rotationally grazed) systems.

Materials and methods
A survey was developed after a review of the literature and in consultation with experts in the relevant fields. Following piloting with 20 farmers, it was published online and advertised via social media channels, farming press, farming levy bodies and unions. Sixty-six follow-up interviews were conducted which asked more open-ended questions and gave farmers a chance to express their thoughts and opinions. A detailed thematic analysis was undertaken on the information gathered during the interviews. Codes were assigned to themes that occur within the data to highlight key patterns and trends, such as between farm type and grazing system used.

Results
A total of 231 respondents completed the survey from across the UK, with a mean age of 49 and a diversity in terms of education levels. Sixty per cent of respondents defined their land type as lowland, 30% as upland, and 10% as a mixture, with a significant range in farm size. The reasons for their current grazing practices were established. Thematic analysis of the follow-up interviews indicates several key barriers to adopting potentially more productive and efficient grazing systems. These include the cost of investment, lack of knowledge and an unwillingness to change. Furthermore, farmers highlighted the inability to provide adequate water and shade to livestock throughout the year as a key barrier. The key enabler highlighted is access to expert knowledge and advice.

Conclusions
Grazing practices play a vital role in the economic and environmental performance of ruminant production systems. Our work creates a baseline of current practices and identifies the key areas that need to be addressed to bring about the transition to potentially more sustainable grazing practices on beef and sheep farms. The results have relevance to ongoing changes to agri-policy towards environmental deliverables and future challenges to the market.

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063

Cattle urine metabolomics from permanent pastures and high sugar grass/white clover swards

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Application
Cattle urine metabolites profiles can offer insight information into the nutritional value of different pastures, and the impacts of animal characteristics on metabolism.

Introduction
Pasture species and location result in different nutrient profiles that affect the metabolic routes of nutrients and their potential animal performance outcomes. Physiological characteristics of the animal can also affect how nutrients are metabolized. Cattle metabolite profile can offer information to identify metabolic routes, pasture utilisation differences and animal characteristics. This study aimed to evaluate differences in the urine metabolomic profile in heifers and steers when grazing different pastures.

Materials and methods
Beef cattle urine metabolites were assessed while grazing at the North Wyke Farm Platform (3 steer and 3 heifers per grazing treatment, n = 18) in spring 2017. Cattle were grazing either a permanent pasture (PP), a perennial ryegrass (high-sugar cultivar) and white clover (GWC) or the same monoculture perennial ryegrass (G) pasture. Snip sward samples were taken once a week over 5 weeks to assess herbage quality parameters. Animals were taken to a livestock handling facility and individual urine samples were taken when voided. Data were analyzed using ANOVA to estimate the impact of pasture types on nutritional quality and the combined impacts of pasture types and sex on metabolite levels. A principal Component Analysis (PC) was applied to identify combinations of key metabolites associated with differences between animals and pasture types.

Results
Pastures had similar nutritional composition in dry matter (DM; 19.6 ± 1.14%), metabolizable energy (12.0 ± 0.26 MJ/kg DM), and ash (8.7 ± 0.07% DM) but differed in crude protein (CP; PP: 22.1, GWC: 18.1 and G: 18.1, SED 2.27% DM, $P < 0.05$) and water soluble carbohydrates (WSC; PP: 13.1, GWC: 15.9 and G: 17.0, SED 0.88% DM, $P < 0.01$). Almost half of the known (77/152) and unknown (273/547) metabolites were significantly linked ($P < 0.05$) to at least one of the effects tested, being that pasture type was the predominant one (75 and 269 for known and unknown metabolites, respectively). The contrast effects showed that most of the significant ($P < 0.05$) effects were between the improved pastures (GWC and G) and PP, with relatively few differences observed between GWC and G. Few metabolites were discriminated by sex (14) or interactions (17). The first two PC account for 78% of the data variation, showing a clear data discrimination of PP from the GWC/G animals by PC1 and PC2 with the weaker discrimination between GWC and G PC2, which was confirmed by the stronger effects that metabolite contributions on the PC were primarily associated with the PP vs. GWC/G contrast.

Conclusions
Cattle urine metabolite profiles differed markedly between improved and permanent pastures, but were minimally affected by animal sex.

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064

Prime lamb production from grazed grass – herbage mineral concentrations in pastures grazed by sheep

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Application
Due to the large range in pasture mineral concentrations herbage should be analysed for mineral concentrations prior to finalising mineral supplementation of ewes and lambs.

Introduction
An adequate intake of minerals is essential for maintaining growth, health and reproduction of livestock; marginal deficiencies can have a substantial impact on performance and health. In lowland grass-based systems of prime lamb production, grazed herbage is a key source of minerals for animals. Management practices (e.g. fertilisation), can influence the concentration of trace minerals in herbage. The objective of this study was to examine the variation in the concentration of trace elements in swards grazed predominantly by sheep in lowland systems.

Materials and methods
Farms (n = 56) were selected, based on geographical location, soil type and farm system, as being representative of lowland sheep producing areas throughout Ireland. Pre-grazing herbage samples were taken monthly (March to November) from 3 selected paddocks on each farm, representative of sward type and age of all paddocks that sheep were grazing. Herbage was cut to the expected post-grazing sward height (4 cm in March and April, 5 cm in May and 6 cm from June to November) by taking 20 cuts randomly within each paddock. A total of 1051 samples were analysed for a suite of minerals as described by Hession et al. (2021). Fifty eight samples classified as having been contaminated by soil (based on the concentrations of Fe, Al, Ti and V) and were removed from the data set.

Results
There was a large range in the concentration of most of the trace minerals in pasture grazed on Irish sheep farms, including elements with well-defined animal requirements (Se, I, Co and Cu). The mean, range (g/kg DM) and CV (%) for the concentration of macro minerals were as follows: Ca 5.08, 0.2–20.9, 28; K 29.2, 9–71, 27; Mg 1.79, 0.7–4.7, 24; Na 1.77, 0.03–11.1, 65; P 4.27, 1.9–10.4, 22; S 3.07, 0.4–11, 31. For trace elements the mean, range (mg/kg DM) and CV (%) were: Co 0.079, 0.01–0.54, 81; Cu 7.80, 0.04–90.3, 65; I 0.43, 0.1–12.8, 145; Se 0.091, 0.003–3.68, 237; Zn 30.9, 12–273, 50; Mn 127.6, 22–856, 79; Fe 113.1, 34–484, 55; Mo 3.16, 0.001–17.4, 71; V 0.12, 0.002–1.1, 118; Cd 0.064, 0.001–0.54, 107; Ni 1.11, 0.1–17.2, 95; B 4.85, 0.01–16.5, 38; Cr 0.41, 0.01–3.9, 123; Al 75.0, 2.5–511, 101; As 0.044, 0.0002–0.95, 114; Pb 0.16, 0.0001–2.1, 99.

Conclusions
Trace element concentrations in herbage from sheep pastures vary significantly, especially Se, I, Zn, Co, Mn and Cu.

Reference

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065

Feasibility of forages mineral analysis with portable X-ray Fluorescence devices

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Application
The mineral content of ruminant's basal diet, mainly composed of forages, is not analysed in routine due to the high cost of traditional analytical methods performed in laboratories. Proposing an innovative handheld analytical tool for cheap and immediate mineral analysis at the farm, will give the opportunity to perform a precise mineral supplementation.

Introduction
Imprecise supplementation of macro (P, Ca...) and micro-minerals (Zn, Cu, Mn...) can result in nutritional imbalances, economic losses, and environmental impacts (Van Emon et al., 2020). Because mineral content in forages is extremely variable compared to total digestible nutrients or protein, proposing a handheld analytical tool is of great interest. The objective of this work was to validate the analysis of selected minerals in forages with several portable devices based on X-Ray Fluorescence (XRF) technique in comparison to wet chemistry method.

Materials and methods
XRF analysis is based on the interaction of X-Ray photons with matter. It is very suitable to determine elemental content of solid samples. In order to validate the feasibility of XRF measurement of mineral content in forages, XRF method was compared to conventional ICP-AES method. Six portable XRF devices were compared. Hay, grass silage and corn silage samples were first collected and then dried and ground. The sample preparation was adapted to be similar to "on the field" conditions. Forage content in sodium, sulphur, phosphorus, chloride, potassium, magnesium, calcium, iron, manganese, copper, zinc and molybdenum was directly determined by XRF. In parallel, the corresponding samples were analysed by ICP-AES. The relationship between XRF and ICP-AES methods was given by the coefficient of determination (R^2) resulting from the linear correlation between XRF and ICP-AES results, using Minitab software (Minitab 21.3.0).

Results
Globally, the correlation between portable XRF and ICP-AES methods was dependent on both element and XRF device. Although, macro-nutrient content (Na, S, P, Cl, K, Mg, Ca) was relatively high in all forages, some minerals were poorly or not at all detected. Sodium was not detected by any portable XRF devices tested in this study. Likewise, magnesium was detected but not quantified with the highest R^2 reaching 0.27. For the other macro-nutrients, R^2 ranged between 0.3 and 0.99 depending on the XRF device. Because of their very low concentrations, micro-nutrients were a challenge for the portable XRF analysis. The hardest to be detected was molybdenum. Only two portable

XRF devices could detect it, with low R^2 (0.1) excluding quantification. Copper, Manganese, iron and zinc were quantified (R^2 between 0.2 and 0.99) depending on the portable XRF device.

Conclusions
These preliminary results showed that due to XRF physical limits, none of the portable XRF devices could provide all element concentrations. Further analytical work will be carried out on selected materials with a focus on sample preparation.

Reference

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066

Modelling the impact of increased DOMD in perennial ryegrass on methane emissions from dairy cows

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Application
This work indicates that methane emissions can be reduced from dairy cows when perennial ryegrass with increased DOMD levels are used. Increasing DOMD in ryegrass therefore represents an important potential mitigation measure to reduce methane emissions while maximising milk yield.

Introduction
There is evidence indicating that diets of higher digestibility can reduce CH4 output per energy-corrected milk yield (ECMY, Knapp et al., 2014). The objective of this study was to assess the potential impact of breeding for increased digestibility in perennial ryegrass on CH4 emissions from dairy cows.

Materials and methods
Methane emissions from dairy cows were predicted using an equation developed from AFBI respiration chamber data (CH_4 = 17.5 * DMI + 99.2*NDFcont − 15.8 * MEcont + 245.6), in which the unit for CH_4 is g/d, for DMI (DM intake) is kg/d, for dietary NDFcont (NDF content) is kg/kg DM and for dietary MEcont (ME content) is MJ/kg DM. This equation was modelled to a grazing dairy cow scenario of 650 kg live weight and 30 kg/d ECMY in which total intake equalled grazed grass intake plus a fixed concentrate input (7.9 kg DM/d). These data were used to model daily CH_4 emissions and CH_4/ECMY for grass of DOMD (digestible organic matter in total DM) ranging from 70% to 75%. These DOMD data were used to estimate grazed grass ME content and then grazed grass intake based on the Feed into Milk models. The same procedure was also used to simulate CH_4 emissions for average DOMD values from three grass data sets: the Feed into Milk database, GrassCheckNI and perennial ryegrass derived from AFBI-bred varieties on The England and Wales Recommended Grass and Clover Lists for 2022 (RGCL).

Results
This CH_4 emission model predicts that CH_4 emissions are reduced along with increased DOMD of grazed grass, with one unit of additional DOMD reducing CH_4 emissions by 0.29 g for every kg of ECMY produced. These data were used to develop a linear regression (CH_4/ECMY; g/kg): $y = -0.286x + 36.4$ ($R^2 = 0.9997$) that indicated a strong relationship between DOMD and CH_4 emissions. For a cow producing 30 kg/d ECMY, the model predicts respectively CH_4/ECMY of 16.4, 15.8 and 14.6 g/kg for grass with DOMD of 70, 72 and 76.7% derived from the Feed into Milk database, GrassCheckNI and AFBI-bred perennial ryegrass varieties on the RGCL 2022.

Conclusions
The current results indicate that providing grass of increased digestibility to grazing dairy cows has the potential to significantly reduce CH_4 emissions, reducing CH_4 emissions by 1.9% per cow with each increase in DOMD of 1%. There is considerable potential for both breeding of new more digestible grass varieties and improving grassland management strategies that can increase herbage DOMD, to reduce methane emissions and contribute to net zero emission targets.

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067

Tannin composition in browse plants as a natural supplement for methane mitigation in ruminants

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Application
Browse plant seeds are effective in reducing methane gas production in ruminants, thereby reducing climate change.

Introduction
The agricultural sector alone has been implicated to contribute approximately 10–20% of the total greenhouse gas emissions due to human activities (Ariom et al., 2022). Oni et al. (2021) reported that nutraceuticals from trees and browse species of high nutritive value can be used as rumen modifier to reduce methane (CH4) gas production in ruminants. Yusuf et al. (2018) reported feeding and CH4 mitigation potential of browse plants leaves, their seeds are yet to find a definite use, and often go into waste yearly, constituting significant environmental pollution.
In this study, we hypothesized that the browse tree seeds (*Albizia lebbeck, Enterolobium cyclocarpum, Leucaena leucocephala, Pterocarpus santalinoides* and *Treculia africana*) would mitigate CH4 production due to the presence of phenolic compounds they contained.

Materials and methods
Mature pods of browse trees (*A. lebbeck, E. cyclocarpum, L. leucocephala, P. santalinoides* and *T. africana*) were collected from the multipurpose tree arboretum of the Department of Pasture and Range Management, Federal University of Agriculture Abeokuta, Nigeria in 2020. The seeds were removed from the pods by threshing and sun-dried for 3 days. Albizia lebbeck, *E. cyclocarpum* and *L. leucocephala* seeds were treated by boiling 500 g of each of the seeds in 1 litre of water on hot plate (Stuart, heat stir, CB162, United Kingdom) with four replicates (100 °C for 15 minutes), while *P. santalinoides* and *T. africana* seeds were treated by toasting of 500 g each of the seeds per replicates on hot plate (170 °C for 15 minutes). The treated seeds were ground to pass through 1 mm sieve using laboratory hammer mill (Model DFZH-Bühler, Uzwil, Switzerland) and analysed for tannin according to the procedures of Jaffe (2003) while in vitro gas production was determined following the procedure of Menke and Steingass (1988). Total gas produced was recorded for a period of 24 h while CH4 gas was determined by introducing 4ml of NaOH into the gas syringes. Data obtained were subjected to one-way analysis of variance with significant means separated at $P < 0.05$ (Duncan's multiple range test) using the SAS software.

Results
There were significant ($p < 0.05$) differences in the tannin content of the seeds, which was highest for *T. africana* (21 mg/kgDM), while the highest total gas was recorded for *A. lebbeck* (33 ml/200 mgDM). Seeds of *P. santalinoides* and *T. africana* yielded the least CH4 and net methane proportion while the other seeds had comparable values.

Conclusions
The browse seeds investigated showed promising potential CH4 mitigation, with *T. africana* yielding the least CH4 gas and net methane proportion of total gas produced.

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068

Nutritive quality of two tropical grasses as influenced by cutting frequency

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Application
Cutting of tropical grasses at younger age produced better quality forage resource

Introduction
The productivity of ruminants in the tropics is dependent on the forage available to them as the major nutrient source (Dele, 2012). Maturity or harvest age have been found to affect forage yield and quality (Ghanbari and Lee, 2003). Therefore, this study aimed to evaluate the effect of two cutting frequencies on the yield and nutritive quality of two tropical grasses (*Cenchrus purpureus* and *Megathyrsus maximus*).

Materials and methods
This experiment was carried out at the Cattle Production venture, Federal University of Agriculture, Abeokuta and laboratory of Pasture and Range Management, Federal University of Agriculture, Abeokuta. The experiment comprised a 2 × 2 factorial arrangement in a split plot design with two cutting frequency (3 and 6-week) and two species (*C. purpureus* and *M. maximus*) with three replicates. The pasture was established in 2019 and this study was carried out in May 2020, the study lasted for a period of eighteen weeks. The harvested samples were weighed, oven-dried at 60 °C for 48 hours and milled. The samples were analyzed for crude protein (CP) (AOAC, 1995), neutral detergent fibre (NDF) (Van Soest et al., 1991) and in vitro dry matter digestibility (IVDMD) (Dele, 2012). The statistical evaluation was done by the analysis of variance (ANOVA) and means separated by Tukey HSD at 0.05 probability level using SAS® 9.0 version.

Results
The dry matter yield was significantly ($P < 0.05$) affected by the species x cutting frequency interaction. The *M. maximus* harvested at 6-week cutting frequency had the highest dry matter yield accumulation (9.13 t/ha DM). The CP ranged from 114.4 g/kg DM to 175.5 g/kg DM, with the crude protein of *C. purpureus* harvested at 3-week cutting frequency been the highest when compared with *M. maximus* at either cutting frequency and *C. purpureus* at 6-week cutting frequency. The NDF of the *M. maximus* harvested at 6-week cutting frequency was the higher than others. The IVDMD (641.8 g/kg DM) of the *M. maximus* harvested at 3-week was superior to other treatments.

Conclusions
The *M. maximus* harvested at 6-week had more dry matter yield and *C. purpureus* at 3-week in terms of crude protein while *M. maximus* harvested at 3-week cutting frequency was better digestible than others.

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069

Essential amino acids of Gliricidia-Megathyrsus mixtures

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Application
The use of blends improved forage quality.

Introduction
The blending of forages especially grasses and legumes have been reported to be good as feedstuff for ruminants (Juknevičius and Sabienė, 2007) as that has helped to balance nutrient (energy vs protein). Bosworth and Cannella (2007) stated that the inclusion of legumes in the feed of ruminants help to promote forage quality, hence animal productivity. This study was to evaluate the essential amino acids as influenced by the different proportion of Gliricidia-Megathyrsus mixture.

Materials and methods
This experiment was carried out at the Pasture Farm Units, Federal University of Agriculture, Abeokuta and laboratory of International Livestock Research Institute, Ibadan, Nigeria. The experiment was a completely randomized design. Megathyrsus maximus was harvested from an already established pasture plot. The Gliricidia leaves were harvested from an already established intensive feed garden (IFG) at the Directorate of University Farms (DUFARMS), FUNAAB. The harvested forage materials were air-dried to constant weight and the two forages were combined into five (5) proportions (treatments) on dry matter basis with five (5) replicates: Sole Gliricidia (100G), 75% Gliricidia + 25% Megathyrsus (75G:25M), 50% Gliricidia + 50% Megathyrsus (50G:50M), 25% Gliricidia + 75% Megathyrsus (25G:75M) and sole

Megathyrsus (100M). The samples were oven-dried and milled. The samples were scanned with NIRS for the crude protein and amino acids contents using the equation for the feed sample analysis based on the mixed feed global calibration model using the software package (Win ISI II FOSS, Denmark, Model NIRS™ 5000) calibrated against convectional wet laboratory analysis. The statistical evaluation was done by the analysis of variance (ANOVA) and means separated by Tukey HSD at 0.05 probability level using SAS® 9.0 version.

Results
The crude protein (CP) content was influenced significantly ($P < 0.05$) by the proportion of the mixtures, with the CP of the sole Gliricidia been the highest and the least Cp was recorded for the sole Megathyrsus. All the amino acids were significantly ($P < 0.05$) affected by the proportion of the mixtures. The sole Gliricidia recorded the highest amino acids concentration except for methionine and leucine as well as valine for which it was statistically ($P > 0.05$) similar with the concentration recorded for mixture with the least proportion of Megathyrsus (75G:25M).

Conclusions
The mixture with the highest proportion of Gliricidia (75G:25M) is recommended as it has the highest CP and most amino acids concentration when compared with other mixtures.

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070

Improved crude protein and *in vitro* gas production of cassava-rich diet containing Leucaena leaf meal

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Application
Inclusion of *Leucaena leucocephala* leaf meal improved the chemical composition and in vitrofermentation of concentrate diet made from crop residues and agro-industrial by-products.

Introduction
Poor nutrient levels of forage in sub-Saharan Africa during the dry season often lead to poor performance or death of livestock, and loss of revenue in smallholder farmers. Crop residues and some agro- industrial by-products are mostly abundant and available resources for livestock feeding (Adelusi et al., 2016), however they are low nutritive value. The use of browse leaves like *Leucaena leucocephala* can augment nutritional deficiencies as it contains relatively high amount crude protein (23.3%) and moderate neutral detergent fibre (40.9%) (Heuzé and Tran, 2016). Thus, the study evaluated the chemical composition and *in vitro* gas production of diets containing increasing levels of *Leucaena leucocephala* leaf meals (LLLM).

Materials and methods
Four (4) diets were formulated to contain (0%, 10%, 20% and 25%) *Leucaena leucocephala* leaf meals. The other ingredients include cassava peels, cassava leaves, palm kernel cake, rice bran, wheat offal, salt, limestone and sulphur. The experiment was set out as a completely randomized design with 4 (4) treatments. The *in vitro* gas production technique employed was that described by Menke and Steingass (1988). A 200mg sample of diet substrate weighed into a fibre bag was replicated eight times ($n = 8$) for each treatment and were placed into 60ml calibrated syringes. Blank syringes containing 20ml of the buffered inoculums only was included as control. Gas volume was recorded for 24 hours period of incubation. Chemical composition of feed was carried out using Near Infra-Red Spectroscopy (NIRS) equipped with globally calibrated equations developed by International Livestock Research Institute (ILRI) from conventional analysis of proximate chemical fractions (AOAC, 2000; Van Soest et al 1991). Data obtained were assessed for normal distribution and then subjected to one-way analysis of variance with significant means separated at $P < 0.05$ (Duncan's multiple range test) using the SPSS 23 software.

Results
Crude protein value of formulated diets increased as the inclusion of LLLM increased with the highest ($P < 0.05$) obtained in diet containing 25% LLLM with 15.59%. Neutral detergent fibre of diets reduced as the level of LLLM increased (43.07% at 25%LLLM). The highest ($P < 0.05$) *in vitro* gas production and organic matter digestibility were obtained at 20% LLLM with a value of 26.67 ml/200mg and 46.30%, up from 20.67 ml/200mg and 39.12% obtained respectively from the control diet containing no leaf meals.

Conclusions
The higher the inclusion level of *Leucaena leucocephala* leaf meal, the lower the fibre fractions of diets, and at 25% inclusion level, the highest crude protein content was obtained. Highest gas production and organic matter digestibility were recorded up to 20% level of inclusion which represents increased rumen fermentation. These result shows good promises for the inclusion of the leaf meal as part of a dry season supplementary diet.

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071 (Invited Speaker)

How animal science can support the role of animals in delivering benefits for society

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Beyond the evidence that a decrease in animal production can limit its environmental footprint, livestock farming systems (LFS) deliver a number of benefits to society, and have feedbacks on cropland production as they influence land productivity by providing manure. We analyse what five options for livestock production and feed use offer for meat and milk production, manure production, cultural ecosystem services (ES), biodiversity conservation, and net greenhouse gas (GHG) emissions from agroecosystems. In line with the CICES classification, we distinguished the cultural ES provided by grassland-based agroecosystems (watching plants and animals, using nature to de-stress) from the conservation of 'undisturbed' natural ecosystems as refuge for biodiversity. Sustainable intensification is an efficiency-oriented option that aims to increase the productivity of agricultural land to limit further loss of undisturbed ecosystems. It could maintain animal protein consumption while preserving biodiversity, but provides a low level of cultural services as the share of permanent grasslands in LFS is limited by their lower productivity compared to crops and leys. This option has the lowest potential for net GHG emissions from agriculture, but C is stored in spared land outside the agroecosystems. Three agroecological options aim to limit LFS dependence on chemical inputs and attenuate feed-food competition. First, feeding herbivores on grass-based diets, and monogastric animals on industry/cropland by-products and food-waste resources, values non-edible feedstuffs while providing animal proteins to humans. Recreational services are high thanks to the central role of permanent grasslands in herbivore diets that contribute to landscape attractiveness for hikers and naturalists. Second, the priority for livestock to provide services to cropping leads to a reduction in livestock numbers. Herbivores graze cover crops and monogastric animals produce animal manure that fully substitutes synthetic fertilizers. Feed resources with low digestibility of nutrients and animal housing are adapted to collective management of manure (e.g., methanisation), whose composition (e.g. N content) is of key importance. The reduction in livestock numbers leads to spare land for nature conservation in marginal areas. Third, human food production becomes marginal when patrimonial LFS are used primarily for biodiversity conservation, which is permitted by European agriculture subsidies that allow these systems to be maintained in upland and Mediterranean areas. Most agricultural stakeholders perceive predation of livestock by wild carnivores as a key issue in the first and third agroecological options. Finally, agricultural rewilding ensures only a limited but high-quality meat production, can support restoration projects, and benefits ecotourism, education and C sequestration. Our analysis opens a challenging research agenda for the animal science community. Key research issues are: (i) how to select animals adapted to fluctuating feed availability and quality, also limiting methane emissions through the selection of traits such as residual feed intake?, (ii) how to feed animals with resources with low N digestibility to maintain milk yield or growth performance while providing manure with high N content?, (iii) how to quantify the consequences of these options (and their combinations) on food production, biodiversity, GHG emissions per ha and per unit of product, and on C sequestration in agroecosystems?

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072 (Invited Speaker)

Livestock in our Landscapes

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National Parks are our most celebrated landscapes. Famed for their natural beauty, abundant wildlife and rich cultural heritage they are also living and working landscapes, forged by the hand of man and particularly that of livestock farmers.
Much of what we see and love in our National Parks continues to owe much to the hard work of farming communities and the livestock they tend, particularly in upland areas. Livestock farming forms the backdrop of many rural communities, supports unique landscape features such as dry-stone walls and is part of a traditional cultural fabric of commoning across many National Parks.
The agricultural transition post-Brexit, market dynamics and a range of policy, societal and environmental pressures on land use are likely to drive significant changes in land management. This will impact on the structure and make up of livestock farming in many of our National Parks, potentially causing significant upheaval to fragile communities. Yet livestock farming is already adapting to demonstrate how it can play an even more important role in helping to shape and enhance the environment of our landscapes.
This presentation will explore the role that livestock play in our landscapes, the pressures and drivers for change and how models of livestock farming are emerging that could form an even more important role in National Parks and other sensitive landscapes. It will explore how farmers can best be empowered to meet the coming challenges including the role that animal science might play.

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073 (Invited Speaker)

Equine anatomical symmetry: Where does normality lie?

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Within a range of species, including humans, asymmetry has been proposed as an indicator of genetic quality through association with factors including disease resistance, mate choice and performance potential. Whilst research into equine movement, or biomechanical asymmetries is a rapidly expanding field, there is to-date, comparatively little research regarding structural asymmetries of the horse. The research being presented includes work undertaken to try to establish the existence, direction and magnitude of distal limb asymmetries within both competitive and non-competitive equine populations. Furthermore, the findings have provided a preliminary picture as to whether a 'normal' level of directional asymmetry exists within the distal limb and hoof of the horse, irrespective of competitive standing. Previously published literature have postulated an association between equine bilateral trait asymmetries and either the locomotor directionality of the competitive discipline, or indeed their associated selective breeding strategies. Similar patterns of distal limb asymmetry were confirmed in event horses, to those previously reported in racehorses. Whilst some event horses are indeed derived from racing bloodstock, the demands of the two disciplines are significantly different. As such, the discipline demand theory of asymmetry development is refuted. Furthermore, the identification of the same patterns of asymmetry in a non-competition population implicates the asymmetries as being present at a species level, as opposed to at a breed, or discipline level. Interestingly, the findings suggest that whilst bilateral asymmetry is present at a species level, horses with a proven superior athletic ability present with less asymmetry, and a greater affinity for symmetry. The asymmetries investigated are not of a magnitude likely to have a significant negative effect on biomechanics. Instead, these asymmetries are theorised to reflect internal disturbances; though of what, and at what structural level, is yet to be determined.
Furthermore, and contradictory to the initial hypotheses, the pliable equine hoof does not compensate for distal limb asymmetries by counteracting for the shorter limb with a longer hoof. Instead, it is suggested that hoof conformation is impacted by the loading imbalance caused by the asymmetries. To compound this further, the asymmetries of the hoof increase within an increase in the size of the horse, suggesting larger horses are subject to both greater, and more imbalanced loading forces; an area of significant concern for both performance and welfare.
Whilst the presentation of structural asymmetries is now better understood, the cause of their development, and their clinical impact is less so.

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074

A preliminary investigation into the effects of equine chiropractic treatment on behavioural and physical indicators associated with diagnosed pain

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Application
Assessment and comparison of physical and behavioural scoring methods of pain indicators and relationship to chiropractic treatment may have implications in improving welfare of horses.

Introduction
Concerns for animal welfare has increased the importance for development of reliable and accessible methods of identifying pain in horses for owners, trainers, and vets. Pain in animals has been investigated using both physical and behavioural indicators within horses who were experiencing diagnosed pain conditions (Haussler & Erb, 2006; Dalla Costa et al., 2016). This study aims to identify if there is a relationship between behavioural and physical indicators of pain when assessing horses not in a specific 'pain state' and after chiropractic treatment.

Materials and methods
Fourteen racing Thoroughbred geldings, mean age ± s.d. = 6.1 ± 1.9 years, were selected with no known existing conditions which could cause an experience of medically recognised pain and discomfort (Dalla Costa et al., 2016). The Horse Grimace Scale (HGS) was used to score the presence of facial action units by trained observers using still images collected from video recordings. Mechanical Nociceptive Thresholds (MNTs) were measured using a Wagner FDK 60 Force Dial at nine identified bony landmarks of the axial skeleton. A randomly allocated treatment group (n = 10) received a McTimoney chiropractic treatment. The control group (n = 4) were palpated only. HGS and MNTs were recorded pre and post treatment/palpation. Datasets assessed for normality by Shapiro-Wilks and pre/post data compared with paired T-tests. Pearson's-Rho assessed correlation relationships between MNTs and HGS.

Results
There was no significant difference (p = 0.8) between mean ± s.d. MNTs pre (11.2 ± 4.5) and post (13.6 ± 4.5) treatment. There was no significant difference (p = 0.9) in mean ± s.d. MNTs pre (10.5 ± 3.8) and post (10.2 ± 3.1) palpation only. The overall intra-class correlation for use of the Horse Grimace Scale between observers showed moderate reliability (0.60). There was a significant decrease (p < 0.001) between mean ± s.d HGS scores pre (0.9 ± 0.4) and post (0.6 ± 0.4) treatment. There was no significant difference in HGS scores (p = 0.19) for the control group. There was no association between MNTs and HGS scores pre-treatment (r^2 = 0.004, p = 0.57) or post-treatment (r^2 = 0.1, p = 0.16).

Conclusions
When using bony landmarks of the axial skeleton, chiropractic treatment has no immediate effect on change in sensitivity to pain measured using MNTs. HGS scores reduced significantly following chiropractic treatment suggesting an improvement in horses' wellbeing and not associated with MNTs. Further research is recommended with larger cohorts, age range, breed types and with horses of known back pain into the relationship between these physical and behavioural indicators.

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075

Use of body condition scoring as an indicator of obesity and metabolic abnormalities in ponies

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Application
Obesity is a significant and highly prevalent health issue in UK leisure horses/ponies. Subjective body condition scoring is used to identify generalised obesity, although it is unclear whether this provides a reliable indication of internal metabolic health.

Introduction
Equine obesity is a highly prevalent health issue in UK leisure horses/ponies (Knowles and Grieve, 2020). It is one of the features that may be present in equine metabolic syndrome, which predisposes equids to endocrinopathic laminitis, a painful and potentially devastating disease (Durham et al., 2019). Obesity is identified using the subjective body condition score (BCS) system. In this study, the correlations between BCS and basal insulin and total adiponectin concentrations in ponies were investigated, as basal hyperinsulinemia and hypoadiponectinemia are independent risk factors for endocrinopathic laminitis (Menzies-Gow et al., 2017; Knowles et al., 2022). In addition, the proportion of obese and non-obese ponies showing one/both metabolic abnormalities was determined.

Materials and methods
BCS, serum insulin, and plasma total adiponectin concentrations previously determined from three cohorts of native-breed UK ponies were analysed. Cohort 1 ($n = 446$) (Menzies-Gow et al., 2017) and cohort 2 ($n = 209$) (Knowles et al., 2022) included clinically healthy, client-owned ponies with no history of laminitis, aged $\geq$7 years. Cohort 3 ($n = 79$) (Wray et al., 2013) included ponies kept at a single horse sanctuary. Of these, 38 had a history of laminitis and 41 did not. Data were pooled ($n = 734$) and correlations were assessed using Spearman's correlation coefficient (ρ). Obese (BCS $\geq$ 7/9, $n = 381$) and non-obese ($4 \leq$ BCS ≤ 5.5, $n = 146$) ponies were divided into the following four metabolic categories: (1) normal basal insulin and adiponectin concentrations, (2) abnormal insulin and adiponectin concentrations, (3) abnormal adiponectin concentrations only, and (4) abnormal insulin concentrations only. These were compared using a Chi-square test of homogeneity followed by post-hoc z-test of two proportions with Bonferroni correction (significance accepted at $P \leq 0.0125$).

Results
BCS was significantly but weakly correlated with basal insulin ($\rho = 0.126$, $P = 0.001$) and plasma total adiponectin ($\rho = 0.293$, $P < 0.001$) concentrations. There were significant differences in the distributions of the four metabolic categories between obese and non-obese ponies ($P < 0.001$). Pairwise comparisons revealed significant differences in the proportion of obese and non-obese ponies with normal concentrations of insulin and adiponectin ($n = 184$ [48.3%] vs $n = 44$ [30.3%]; $P < 0.001$) and those with hypoadiponectinemia only ($n = 58$ [15.2%) vs $n = 56$ [38.6%], $P < 0.001$). There were no statistically significant differences in the proportions of obese and non-obese ponies with hyperinsulinemia only or abnormal concentrations of both.

Conclusions
BCS does not closely reflect basal insulin or adiponectin concentrations as the correlations, although statistically significant, are very weak. A greater proportion of obese ponies had normal insulin and adiponectin concentrations than their non-obese counterparts, suggesting that a sub-group of obese ponies may be metabolically healthy. Furthermore, a greater proportion of non-obese than obese ponies showed hypoadiponectinemia. Taken together, these findings suggest that BCS alone is not a reliable indicator of basal hyperinsulinemia or hypoadiponectinemia, which are two important risk factors for laminitis in ponies.

Acknowledgments
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076

Faecal near infrared prediction of dietary fibre fractions of equine diets

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Application
Faecal near infrared reflectance spectroscopy has the potential to predict dietary composition of grazing horses and even a greater impact on the management of feral horse populations.

Introduction
Faecal near infrared reflectance spectroscopy (NIRS) has been used for the prediction of dietary nutrient component in several animal species such as cattle, sheep, goat, rabbit and pig but with limited use for horses. This study examined the potential use of faecal NIRS for the prediction of fibre fractions in horses' diets.

Materials and methods
Diet (D) reference data and faecal (F) NIR spectra pairs (D:F) were obtained from two independent feeding experiments using 29 horses for the development of predictive models. Each horse was offered a unique diet each week comprising of hay or haylage, and concentrate supplementation. Each experiment was conducted for five weeks (one week adaptation and four weeks of measurements). Sub-samples of diet and faeces were pooled per week per horse (n = 116). For the development of calibration models, samples from weeks 1–3 (n = 87) were used while samples from week 4 were used as independent validation set (n = 29). Calibration models were developed by modified partial least square regression. Various spectra pre-treatment and mathematical treatments were also applied. Optimum predictions were selected based on ratio performance deviation (RPD), coefficient of determination of validation (R2val), standard error of prediction (SEP), bias and slope.

Results
Faecal NIRS prediction of neutral detergent fibre (aNDF) was very good (R2val = 0.83 and RPD = 2.12). While a less satisfactory (R2val = 0.77 and RPD = 1.56) prediction model was obtained for acid detergent fibre (ADF) it was still acceptable. The poorest prediction was obtained for acid detergent lignin (ADL) (R2val = 0.41and RPD = 1.05). Optimum predictions for all the fibre fractions were obtained from spectra collected from the Visible NIR (Vis-NIR) wavelength region.

Conclusions
Overall, this study confirms that faecal NIRS can be used to successfully predict aNDF in horses' fed mixed diet of forage and concentrate.

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077

Phenotypic and genetic characterisation of disease subtypes of equine recurrent exertional rhabdomyolysis

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Application
Identification of clinical subtypes of RER improves our ability to study the genetic basis and aetiopathogenesis of the disease, as well as seek potential treatments. This improves the welfare of the animals as well as having an impact on the huge financial losses suffered by the racing industry due to RER.

Introduction
Equine recurrent exertional rhabdomyolysis (RER) is a myopathy characterised by exercise-induced episodes of myofibre necrosis. RER is clinically heterogenous, with variation between clinical signs and severity of those signs between individuals and between episodes, with severe cases resulting in recumbency, kidney failure and even death. RER is a moderately heritable disease (h2 = 0.34–0.49) (Norton et al., 2016), but causal genetic variants have not yet been identified. Previous studies in another exertional myopathy, polysaccharide storage myopathy, identified disease subtypes with differing genetic basis (McCue et al., 2008, 2009). We aimed to identify possible disease subtypes within the RER syndrome.

Materials and methods
We applied principal components analysis, k-means clustering and hierarchical clustering methods to 209 RER horses retrospectively from the Royal Veterinary College's Comparative Neuromuscular Diseases Laboratory diagnostic biopsy service, to identify clusters of cases based on clinical history and histological records. We then tested variables for association with clusters using Chi-square testing.
A support vector machine algorithm was trained successfully to differentiate between classic and non-classic RER cases, and this algorithm was applied to a dataset of 127 Warmblood horses (WB) and Connemara ponies (CP) (CP: 16 cases, 17 controls; WB: 50 cases, 44 controls). Genome-wide association studies (GWAS) were carried out within and across breed and disease subtype.

Using 69 samples of equine semimembranosus muscle from Arabian, Thoroughbred and WB horses (24 classic RER, 12 non-classic RER, 26 negative controls, and 7 with myofibrillar abnormalities), we carried out a blinded histological study comparing features identified by a specialist between disease groups from a standard panel of myopathy staining and immunohistochemistry, including for desmin. We selected features with $p < 0.1$ on a univariate contingency table or two-way ANOVA for inclusion in a binary (between the subtypes) or multinomial logistic regression model.

Results
Consistently, horses grouped into 'classic' and 'non-classic' RER subtypes: cases with no particular defining features, versus cases associated with gait abnormalities ($p < 0.001$), muscle pain ($p < 0.001$), weakness ($p = 0.001$), ataxia ($p = 0.001$), and reluctance to move ($p = 0.001$). GWAS identified different patterns of genetic associations between breeds and between the disease subtypes. No convincing histological differences were identified between the disease subtypes, supporting our clustering analysis, and indicating that any histological differences between disease subtypes are not captured by current staining panels.

Conclusions
Overall, RER is a complex disease, likely consisting of multiple disease subtypes with possible distinct genetic associations.

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078

Microbiological etiology of infectious infertility in Arabic mares

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Application
Bacterial infections of the uterus are known to be an important cause of infertility in the mare. The objective of this study was to determine species of bacteria isolated from the uterus of infertile Arabic mares, and verify how identified bacteria related to parity.

Introduction
Bacterial infections of the uterus are known to be an important cause of endometritis and reduced fertility in the mare (LeBlanc et al., 2007). It should be noted that, frequent occurrences of acute endometritis may cause the pathology related with chronic endometritis, with mucociliary dysfunction (4). In chronic endometritis, biofilm forms in the endometrium that provides an adhesive environment for bacteria. It is told that, some bacteria such as E. coli produces a biofilm that protects itself and other microorganisms from the inflammatory response (5). Due to the problems that clinicians face in impregnating mares with endometritis, this study has tried to determine the causes of endometritis resistant to routine treatments.

Materials and methods
A total of 18 Arabic mares with a history of long term infertility were evaluated. The mare's age range was from 4 to 23 years old. In this study, low-volume uterine flush and culture technique was used. In statistical analysis, logistic regression and Chi-square test were used by Proc Logistic of SAS.

Results
Pseudomonas aeruginosa was the most prevalent bacteria isolated (26.32% of mares) that isolated as pure or conjunction with Escherichia coli, Klebsiella pneumoniae or Citrobacter spp. Furthermore, 23.68% of bacterial infertility was related to Escherichia coli. Pure growth of E.coli was seen only in one case. But the mixed growth with Pseudomonas aeruginosa, Streptococcus zooepidemicus and Staphylococcus aureus was very prevalent. The present study revealed that the most prevalent bacteria isolated from chronic endometritis in Arabic mares were gram negative bacteria ($p < 0.05$), but in some cases may be accompanied by gram positive bacteria. Candida albicans was isolated in only 8% of mares with chronic endometritis. Also, an increasing age and parities number of the mare was not related to the presence of intrauterine fluid or the species of bacteria ($p > 0.05$).

Conclusions
It can be concluded that, the most prevalent bacteria isolated from infertile Arabic mares with chronic endometritis, are gram negative bacteria.

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079

Response of 24 and 30-month old Warmblood stallions to preparatory training for stallion licensing

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Application
Training of sport horses before the age of three years is often critically discussed. Results of our study will help the equine industry do decide on changes in the minimal age requirement of horses entering training.

Introduction
While information is available on performance and musculoscelatal health of young horses in training, the stress response of these horses to pre-training and training has not yet been studied. Objectives of our study (*HorseWatch* project) are the analysis of body development, heart rate (HR), and heart rate variability (HRV), in young stallions during preparation for breed registry licensing.

Materials and methods
Warmblood stallions (n = 16) were followed for 12 weeks during preparation for stallion licensing starting at 24 and 30 months of age. Body weight was assessed on a scale. Analysis of HR andf HRV was performed with Kubios software after recording cardiac beat-to-beat intervals with a mobile system (Polar V800, Kempele, Finland). The 24-months old stallions were either kept in a group (n = 5, Group 1) or in single boxes (n = 5, Group 2) and 30-months old stallions were kept in single boxes (n = 6, Group 3). All stallions had been kept in groups on pasture before. The three-month training programme included free movement in a riding arena, lunging, jumping of obstacles without a rider and movement in a horse walker with increasing demands. The HR and HRV response to 12 of these training units was analysed in the stable and continuously from 60 min before to 120 min after training. In Week 3 and 12, a standardized lunging test (10 min walk, 10 min trot, 3 min canter) was performed. Data were analysed by repeated measures ANOVA (IBM-SPSS software) with time as within and group as between subject factor. Values are mean ± SEM.

Results
Mean Initial body weight did not differ among groups and was 493 ± 6 kg. Irrespective of group, body weight decreased to 83 ± 8% of initial weight in Week 1 after transfer from pasture to stable and increased thereafter (p < 0.001). Initial weight was reached again in Week 4 (Group 3), 5 (Group 1) and 7 (Group 2), respectively. HR increased during all training units (p < 0.001) with similar peak values in all groups (n.s.). At rest, HR was higher in Group 1 than in Group 2 (p = 0.006). The HRV (standard deviation of the cardiac beat-to-beat interval, SDRR) decreased during training units (p < 0.001) without differences among groups. During the lunging test, HR increased from <40 beats/min at rest to 131 ± 5 beats/min in trot and 164 ± 5 beats/min in canter irrespective of group (n.s.).

Conclusions
Present results do not suggest differences in the response to pre-equestrian training in stallions started at 24 or 30 months of age. Accommodation type did not influence the results. Data are currently supplemented by analysis of the adrenocortical response and behaviour.

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080 (Invited Speaker)

What do businesses need from animal science? A meat processor perspective

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What do businesses need from animal science....? Everything!
All commercial activities linked to animals, be they companion animals or livestock need strong science-based evidence and educated independent evaluations of the practical applications of that science. For biological systems this is often easier said than done and even more so for animal science.....
Meat is the end product from the life of any given food animal and the quality of the meat we process is the result of the interaction of that animal with it's environment in the very broadest sense be that:

- Food & digestion
- Disease susceptibility/resistance
- Fertility
- Genetics
- Muscle/fat/conformation/organoleptics
- Rumen biology
- Climate change – ability to cope with changing environments

These interactions may be positive or negative and the validation of these interactions and a good understanding of the cause/effect is crucial. In a commercial context we have to be sure that they don't have any unintended consequences.....
As a meat processing business, we rely on animal science to inform and guide us and to provide us with the evidence and opportunities to demonstrate to our customers and our suppliers, as well as to the general public and consumers that our UK production systems and our high quality food processing systems are the best in the world.

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081 (Invited Speaker)

What do businesses need from animal science?

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As a business we need to look for the return in investment... so what is the problem worth?
A business needs a balanced stakeholder group within the R & D function. The stakeholder group should involve both commercial and technical input and will be partly responsible for identifying areas of innovation. The end user should be in focus at all times.
Through horizon scanning we can look at what we envisage the future landscape to be. The horizon constantly changes so looking ahead must be a continuous process. What may be relevant today may not be tomorrow, while the unknown remains the unknown.
Establish identified needs and then move on to the innovation ideation process. The first question should always be, 'how much is the problem worth?' A solution should not come at a higher cost than the problem. If a problem grows in size so can the need and value of a solution. Research can be both reactive and proactive. There needs to be a balance of immediate needs with long term requirements and projects prioritised based on both need and return. A completed business plan and an agreed upon stage gate process will keep a project on track and allow for deviation and reprioritisation as required. Not all projects will make it to the finish line, but no research is wasted. If

a project is put on hold or deprioritised, we need to learn to fail or not to fear failure, as sharing lessons learnt through this process is valuable.
Collaboration in the wider industry plays a pivotal role in the validation process. Independent assessment of products or claims will allow for a level playing field which benefits the end user. Expert advice from the research community is key to removing bias.
An innovation at launch needs to offer a minimal viable solution rather than perfection. Further validation will lead to continuous improvement and the evolution of further solutions. 'Perfection' is not a prerequisite for a successful output.
The research community can be instrumental in offering advice that can inform legislation, but the consequence of change can be detrimental or impractical to business. This is where closer collaboration and understanding can support both areas. It is great to solve a problem, but at what cost and who ultimately pays?
The scientific community plays an integral part in developing the next generation of industry professionals. Today's research students are potentially tomorrow's colleagues. Industry actively supports degree placement students to sponsored PhD candidates as regenerating industry with fresh ideas and talent from the scientific community aids in driving progress.
Collaboration between science and industry is pivotal to both current and future business success.

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082 (Invited Speaker)

An academic perspective – How research has already delivered benefits to industry

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Constructive, collaborative partnerships between academia and industry are the cornerstones of animal science research worldwide. These relationships are synergistic – from an industry perspective, the development of new technologies, innovations and management practices is dependent upon evidence-based, peer-reviewed literature to back marketing claims and, where applicable, to fulfil legislative requirements. On the academic side, animal science research without current or future industrial application may be considered to lack value. Although the ''research for research's sake" concept could be applied to some academic fields, academic success within animal science, whether measured in terms of grant monies, career promotion or industry network size, is largely dependent upon the applicability, adoptability and importance of the research topic. Notable examples of research programmes that have successfully translated into changes in livestock sector practice include the pioneering behavioural work by U.S. Professor Temple Grandin that transformed cattle handling across the global beef industry; the early reproduction studies by Sir John Hammond CBE that provided the foundation for artificial insemination and other reproductive techniques; and the advances in livestock nutrition facilitated by many of the researchers presenting at this conference. In recent years, organisations such as the Centre for Innovation Excellence in Livestock (CIEL) have fostered and facilitated intersector partnerships which, when successful, these can deliver results with myriad benefits. However, conflicting pressures can threaten these alliances. The greatest threat is the divergence between the industrial value of outreach, knowledge transfer and engagement (i.e. research being effectively communicated and translating into technology adoption or behavioural change) vs. the academic need to publish in high-impact journals. Both are important, yet often appear to be diametrically opposed. The academic focus on gaining funding to support both research and, via overhead costs, the wider infrastructure of the academic institution, may skew research away from industrially valuable yet low-cost projects that potentially evoke wide-scale change, towards the economically lucrative that may have a lesser impact. This is complicated by the increasing trend for those opposed to research findings to ''follow the money", claiming that industry funding inevitably leads to biased results. Finally, although the ideological ivory tower may be less prominent within the animal science field than other research areas, there is often a considerable difference between feasible academic and industry timelines. Complicated by competing pressures from teaching and other scholarly activity and the restrictive deadlines and timescales of competitive grant calls, the potential for new projects to be executed within days or months is low. Considerable research gains can be achieved from academia-industry partnerships, yet success depends on navigating the aforementioned hazards and implementing models that place appropriate value on both academic and industry priorities.

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083 (Invited Speaker)

Approaching greenhouse gas emissions from dairy at farm level

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In 2019, Arla Foods launched climate ambitions including a science-based target (SBTi) 30% reduction of scope 3 emissions (including on-farm emissions) by 2030.
In order to assess emissions and define reduction levers, the climate check programme was introduced in 2020. It is based on an attributional LCA according to IDF guidelines and developed by 2.0 LCA consultants (https://lca-net.com). In addition to the LCA calculator, Arla has developed a web-based data entry surface and a results platform including a working environment for data verifying advisors.
The first years of data collection revealed that over 70% of the variation between high and low performing farms can be explained by performance in five key management parameters: feed efficiency, feed protein efficiency, cow mortality, N fertiliser use and land use. Hence, there is a high potential for reducing GHG emissions via improvements in management and efficiency on farm. It is estimated that up to 8% of the milk carbon footprint can be reduced by improvements in these key areas, also called ''Big 5".
Benchmarking farms against each other, it turns out that only 11 out of 7700 farms are high performing (top quartile) in all management parameters. The majority of farms has a mixed performance doing well on one or two parameters and with clear improvement potential on other parameters. Hence, a huge potential lies in the improvement of low or moderate performers.
Farmers are supported by climate check advisors, who are contracted and trained by Arla. Their task is to validate the data input, generate and explain results and point out individual strengths and improvement areas on farm. Generally, farmers reflect positively on the climate check (score 4.0 of 5 in 2022 farmer satisfaction survey). However, accelerating reductions on farm calls for change management and for supporting all farmer owners on the journey – ensuring Awareness, Desire, Knowledge, Ability and Reinforcement (applying ADKAR model). The climate check program with annual calculations of the farm carbon footprint and an annual 1:1 visit between farmer and advisor has served a fundamental part in increasing awareness in the first two years, together with communication to ensure farmers understand the need for reducing GHG emissions, and which elements affect the milk carbon footprint. From 2023, Arla will introduce an ambitious payment model to stimulate desire to move ('a pull for reductions').
Alongside with focused activities on knowledge sharing, competence development and an increased collaboration with advisory organizations, industry representatives and important stakeholders we enable farmers to take action for the climate and ensure to have trusted advisors available to guide and support.

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084

Creating a generalisable equation to predict enteric methane emissions from dairy cattle

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Application
Provide a universal enteric methane prediction equation that accounts for unexplained sources of variation.

Introduction
There are several methods for collecting the enteric methane emissions of dairy cattle (Hristov et al., 2018). However, predicting enteric emissions using equations is economical, less labour intensive, and does not require specialist equipment unavailable to most farms (Appuhamy et al., 2016). Predictive equations estimate enteric emissions based on various dietary composition variables and vary considerably in their results, due to variations in methodology such as cow type and the measurement equipment used in their development. Without a universal equation, it is difficult to make comparisons between enteric emissions. Therefore, the aim of the current study was to establish a generalisable equation, to harmonise the predictions from published equations.

Materials and methods
''Science Direct" was used to find current equations, resulting in 101 international equations, which were coded into R programming language and 15 dairy cow diets commonly fed in the UK were formulated, as inputs for the equations. The equations based on single variables, milk production variables and those that produced implausible results were removed, resulting in 32 equations. The results were summarised as grams per kilogram of dry matter and the correlations between the dietary composition variables in the equations were assessed. Multiple mixed effects regression models were built, using the results from the 32 prediction equations across the array of diets, with the random effect of study to account for differences in collection methods and experimental populations. The performances of the equations containing various combinations of dietary characteristics were analysed, using their significance, r-squared, root mean square error and against the published equations predictions.

Results
Twelve possible dietary composition combinations for the generalisable equation were determined. The correlation matrix highlighted strong correlations between variables metabolizable energy with ether extract and crude protein. Analysis of the range of mixed effects model results, revealed three similarly significant combinations of variables. Metabolizable energy and neutral detergent fibre were chosen for the generalisable equation based on their wider data accessibility, best model fit, r-squared (0.79), and root mean square error (1.47%).

Conclusions
The predictions from the published equations, using commonly used diets in the UK, established the variables metabolizable energy and neutral detergent fibre, as the most suitable for use in the generalisable equation. Our study provides a universal equation for predicting the enteric methane emissions of dairy cattle, using dietary composition data.

Acknowledgments
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085

Effects of fresh or spent hops (*Humulus lupulus*) on enteric methane production *in vitro*

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Application
Fresh but not spent hops are a potential methane inhibiting ruminant feed additive.

Introduction
Enteric fermentation by ruminants is a major contributor to global greenhouse emissions. Research has identified many feed additives that have anti-methanogenic properties including plants containing bioactive metabolites. Hops (*Humulus lupulus*) are known to possess antimicrobial properties, making them a potential feed supplement to reduce enteric methane emissions by ruminants. Previous studies *in vitro* have shown negative effects of hops and hop extracts on methane production rumen fluid fermentation systems (e.g. Narvaez et al., 2013). The objective of the present study was to determine the effects of dietary addition of fresh or spent hops on rumen methane production *in vitro*.

Materials and methods
Fresh or spent hops (variety Chinook) were added to a total mixed ration (TMR) at 5% or 10% of dry matter. Fresh and spent (obtained following home beer production) hops and TMR were dried at 60 °C and ground (1 mm screen) before mixing. Replicates (3) of control and treatment TMR samples were added (1 g/bottle) to 90 ml of anaerobic incubation buffer and 10 ml of rumen fluid in a sealed 150 ml glass bottle purged with CO_2. Blanks that only received rumen fluid were included to correct for background gas production. Fermentation bottles were incubated at 39 °C for 8 hours and measurements of gas production (head space pressure) and methane concentration (gas chromatography) were obtained at 2, 4, 6 and 8 hours. Data were analyzed by Mixed models for fixed effects of treatment and means separated by Dunnett's comparisons.

Results
Total gas production was increased ($P < 0.03$) by adding 10% spent hops, but not affected by other treatments. Total methane production was reduced 29% by 10% fresh hop addition ($P < 0.02$) and increased 23% by 10% spent hop addition ($P < 0.04$), reflecting the increase in total gas production observed. Spent hops had no inhibitory effects, suggesting hop bioactive components may be lost during fermentation for beer production.

Conclusions
The methane mitigation potential of hops as a dietary feed additive deserves further investigation, although it appears that as a by-product of the brewing industry spent hops are not effective as a methane inhibiting feed additive as fresh hops.

Acknowledgments
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086

Seasonal greenhouse and ammonia gas emissions in a naturally-ventilated dairy housing system

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Application
The understanding of gases emitted in dairy housing systems is essential for the development of management practices and emission factors to reduce their environmental impact and inventory purposes, respectively.

Introduction
In the UK, ruminant livestock production poses the largest environmental challenge in the agri-food sector. The understanding of ammonia and greenhouse gas emissions in dairy housing systems during different seasons of the year is essential for the development of management practices and emission factors to reduce their environmental impact. This study aims to estimate and analyse NH_3, CO_2, CH_4 and N_2O gases emitted during different seasons of the year in a naturally-ventilated dairy barn using a multichannel photoacoustic and CO_2 balance method.

Materials and methods
Emitted gases were monitored, August 2020–June 2021, in a naturally-ventilated dairy house (70×21m) at AFBI Hillsborough with loose housing, cubicles and solid-slurry-floor system (3h scraping intervals). Concentrations (ppm) of NH_3, CO_2, CH_4 and N_2O inside and outside the house were measured using a photoacoustic monitor (INNOVA 1512, LumaSense Technologies) and a 24 multipoint channels sampler (sampling intervals of 72 seconds/point; INNOVA 1409, LumaSense Technologies). Sampling lines, 19 indoor and 5 outdoor, were distributed according to VERA's protocol. Cows and environmental parameters were measured during gas monitoring. Cow's CO_2 emissions were estimated from DM intakes (Chen et al., 2021). Nitrogen (N) excretion in faeces and urine was estimated from measured N intake. Daily air flow rates through the house were calculated using the CO_2 balance method (VERA, 2018) and used to determine NH_3, CO_2, CH_4 and N_2O emissions. Response variables were analysed using a linear mixed model via the REML, with season as the fixed effect and date as a random effect. Pairwise differences between treatments were examined using the Tukey's test ($P \leq 0.050$).

Results
Methane emissions per livestock unit and DM intake were lower ($P < 0.0001$) in summer, whilst CH_4/energy corrected milk yield (ECMY) was lower ($P < .0001$) in winter. Nitrous oxide production and as a proportion of manure-N were lower ($P < 0.0001$) in Summer and Spring, whilst N_2O/ECMY was lower ($P < 0.0001$) in Winter and Spring. Finally, NH_3 production, ECMY and as a proportion of urine-N were significantly lower ($P < 0.0001$) in winter.

Conclusions
Methane and CO_2 emissions were within the range of those measured in respiration chambers published elsewhere. Ammonia-N/urine-N emissions showed seasonal variations that should be considered in the UK inventory models for updating annual NH_3 inventories. Nitrous oxide emissions showed significant seasonal variation across the year.

Acknowledgments
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087

AFBI's 30-years research on quantification and mitigation of methane emissions in cattle and sheep

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Application
AFBI cattle/sheep methane (CH4) emission data are a major component of the UK wide database and have been used to develop and update UK greenhouse gas emission inventories.

Introduction
The UK has committed to net zero carbon by 2050. Achieving these ambitious targets require the development of accurate estimates of greenhouse gas emissions (GHG) from key sectors. Since 1992, AFBI has generated data from enteric CH4 emissions in cattle and sheep. Databases are used to develop GHG emission calculators and develop mitigation strategies for specific farming conditions.

Materials and methods
Since 1992, AFBI has undertaken more than 80 studies (the majority in dairy cows) evaluating the effects of a range of dietary, animal and management factors on enteric CH4 emissions from dairy cows, growing cattle and sheep under a range of farming conditions. Technologies such as indirect open-circuit respiration calorimeter chambers, sulphur hexafluoride tracer technique, and more recently GreenFeed units and a photoacoustic gas monitoring system have been used to evaluate the effects on CH4 emissions for grazing and indoor feeding cattle and sheep. The result reported here was produced from CH4 emission data measured from more than 1,200 dairy cows, 300 growing cattle and 200 sheep using cattle and sheep respiration chambers.

Results
Average AFBI respiration calorimeter CH4 data in dairy cows, growing cattle and sheep are 358 (from 124 to 582), 170 (from 68 to 291) and 23 (from 7 to 42) g/day, respectively. The corresponding data in CH4 emissions per kg dry feed intake are respectively 22.3 (from 10.9 to 30.2), 24.0 (from 11.7 to 33.9) and 19.7 (from 10.6 to 33.9) g/kg. Enteric CH4 emissions from individual cattle or sheep vary considerably, because the emission not only relates to total feed intake, but also is influenced by animal genetics and a range of dietary factors (e.g., concentrate input, forage type and dietary quality). Statistical modelling, using AFBI's CH4 data, indicates that enteric CH4 emissions per kg milk or feed intake can be reduced through the selection of highly efficient animals, feeding good quality forage, dietary manipulation for balanced supply of protein and energy to maximise rumen microbial activity, and dietary inclusion of feed additives to restrict rumen methanogens activity. These results have been implemented in a range of prediction equations developed using AFBI's CH4 data which provide an alternative approach for quantification and mitigation of enteric CH4 emissions in cattle and sheep production under various farming conditions where directly measured CH4 data are unavailable.

Conclusions
AFBI's 30-years research has shown that daily CH4 production is affected by total feed intake, and individual variations are attributed to animal genetics and dietary factors. These results have been used to develop NI dairy and beef GHG emission calculators and update UK GHG emission inventories. AFBI's current scientific work focuses on the development of novel methane-mitigation strategies through the AFBI-QUB Strategic Alliance and international collaboration.

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088

Investigating chlorate in water as a cause of chlorate in milk

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Application
The findings of this laboratory based experiment suggest that waters with increasing total chlorine levels will have increased chlorate levels and should that water come into contact with milk it has the potential to cause chlorate contamination of said milk. This study provides the information needed to design targeted field based experiments that are required to establish the trends and behaviours of chlorate in water when used as part of the cleaning process on dairy farms and its impact on milk residues and is requisite for the betterment of the dairy industry in terms of its understanding of contamination of farm bulk milk with chlorate as a consequence of chlorinated water use.

Introduction
Chlorate; a product of chlorine degradation has emerged as a residue of concern across the international dairy industry in recent years due to its goitrogenic health implications and the subsequent effect that this has on market demand. Chlorine based chemicals used for cleaning milk contact surfaces are viewed as being a primary source of chlorate contamination in milk. In addition to this, chlorinated water is also mooted as a potential cause of chlorate residue in milk where it is used as part of the milking equipment cleaning routine (McCarthy et al., 2018).

Materials and methods
To establish if water containing chlorine results in chlorate residue in milk, a laboratory experiment was conducted where 24 test samples were created using chlorine free well water and an 11% sodium hypochlorite product in batches of 6; at 4 different time points over a 6 month period in 2021; with waters chlorinated to achieve the following levels in each batch; 0.50 mg/L, 1.00 mg/L, 1.50 mg/L, 2.00 mg/L and 2.50 mg/L of total chlorine respectively (non-chlorinated well water was the control). These waters were frozen, defrosted and analysed for chlorate in triplicate. These same waters were then used to spike 24 individual 100 ml milk samples at a rate of 2%; followed by inversion, freezing at −20 °C and chlorate analysis (when defrosted). Both waters and milks were analysed for chlorate using ultra performance liquid chromatography coupled with tandem mass spectrometry with a minimum level of detection of 0.00020 mg/L and 0.0020 mg/kg respectively.

Results
Increasing levels of chlorate were displayed ranging from 0.0021 mg/L to 0.68 mg/L in the waters; increasing in line with chlorine concentration and sodium hypochlorite age. The spiked milks displayed increasing levels of chlorate ranging from <0.0020 to 0.013 mg/kg; similar to the trend displayed by water chlorate levels.

Conclusions
The presence of chlorate at detectable levels in spiked milks indicates that chlorate in water can result in chlorate contamination of milk when both water and milk make direct contact. Furthermore, this study suggests that water containing higher levels of chlorate poses a greater risk to milk as it will likely result in greater levels of chlorate contamination. Further investigations are needed at farm level to determine the practical impacts that chlorate in water has on chlorate in milk where it is used as part of the milking equipment cleaning regime.

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089

Human edible feed efficiency within contrasting milk production systems

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Application
Improvements in human edible feed efficiency can be achieved through reductions in concentrate feed rate.

Introduction
While the dairy sector makes a significant contribution to supplying the nutrient needs of a growing global population this is being achieved through increased use of grains and pulses in diets of cows with higher yield potential. Research must develop sustainable feeding systems that rely more on using human inedible feeds. This study was designed to assess human edible feed use efficiency within a range of Northern Ireland milk production systems.

Materials and methods
The performance of Holstein and Holstein * Jersey cows were evaluated across 4 production systems, Winter calving – fully housed (WC-FH), Winter calving – conventional (WC-Con), Spring calving – Holstein (SC-H) and Spring calving – Jersey x Holstein (SC-J*H) over 3 lactations (described in full by Ferris et al. (2021)). Various performance indicators describing feed conversion rate were calculated for each system based on mean data recorded over 3 years. Feed conversion efficiency (FCE) was expressed as kg milk per kg dry matter intake (DMI). Edible feed conversion ratio (eFCR) (energy) was calculated as daily human edible gross energy (GE) output per daily human edible GE input. Net food production (NFP) (protein) was expressed as daily human edible crude protein (CP) output minus daily human edible CP input. Net protein contribution (NPC) was the product between the Protein Quality Ratio (PQR) and the eFCR (protein), where PQR was calculated using Digestible Indispensible Amino Acid Scores (DIAAS) for human edible elements.

Results
Milk yields and concentrate feed rates for WC-FH, WC-Con, SC-H and SC-J*H were 9333, 8443, 6464 and 6049 kg/cow ($P < 0.001$) and 0.38, 0.30, 0.13 and 0.14 kg concentrate/kg milk respectively. FCE (kg milk/kg DMI) was 1.47 (WC-FH), 1.47 (WC-Con), 1.42 (SC-H) and 1.34 (SC-J*H). Human edible GE intake as a proportion of total GE intake was 0.22 (WC-FH), 0.17 (WC-Con), 0.07 (SC-H) and 0.08 (SC-J*H). eFCR (energy) for WC-FH (1.18) and WC-Con (1.51) was over 50% lower than values calculated for SC-H (3.81) and SC-J*H (3.70). NFP (protein) (g/cow/ day) were −43, +204, +450 and 434 for WC-FH, WC-Con, SC-H and SC-J*H respectively. NPC values for all treatments were positive (WC-FH, 2.1; WC-Con, 2.6; SC-H, 4.3; SC-J*H, 4.1).

Conclusions
Human edible feed conversion efficiency parameters recorded in this study were similar to those recorded in the literature. Human edible feed conversion efficiency appeared to improve with reductions in concentrate feed rate. Although some treatments had a negative Net Food Production value, all treatments had a positive value for protein contribution.

Acknowledgments
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090

Effect of a molasses based liquid feed on diet digestibility, volatile fatty acid production and methane emissions in lactating dairy cows

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Application
Changes in rumen VFA profile leading to enhanced milk composition with no change in methane production supports the use of molasses based liquid feeds (MBLF) as a sustainable strategy to improve animal health and efficiency.

Introduction
The use of MBLF can significantly increase fibre digestion, increase nitrogen retention, total volatile fatty acid (VFA) production and rumen pH (Penner and Oba, 2009; Broderick et al., 2008) thus increasing the efficiency of use of home grown forage and reducing the need for additional protein supplementation. Limited research has found that sucrose has a neutral impact on methanogenic populations in the rumen and favours butyrate production in the rumen resulting in fewer free hydrogen ions and potential methane production, which lends itself to the hypothesis that methane production should be neutral or lower for cows with higher sugar diets.

Materials and methods
A total of 28 cows were used in an 8-week Latin crossover consisting of two 4-week periods, and 2 diet treatments, including the basal farm diet and the treatment diet where 1.4 kg of concentrate DM was replaced with the MBLF 'Regumix' on a CP equivalent basis. Animals were housed in a cubicle yard with individual feed stations, free access to water and were milked twice daily.
Measurements included daily diet dry mater intake (DMI) and nutritional composition, milk yield (MY) and composition, rumen pH and VFA. Four of the 28 cows underwent additional measurements of total tract digestibility by total faecal and urine collection, while housed in respiration chambers also measuring CH4 emissions. Data was statistically analysed using the Mixed procedure of SAS® and a model testing fixed effects of treatment and the random effects of cow and period.

Results
There was no effect of diet on DMI and MY. Milk fat concentration increased ($P < 0.05$) in cows receiving MBLF. Methane production and intensity in relation to DMI and MY was similar for both treatments. The total tract digestibility of nutrient fractions was similar for both diets with the exception of NDF which was lower ($P < 0.01$) for MBLF. A reduction in milk nitrogen g/day ($P < 0.05$) and increase in urinary nitrogen ($P < 0.05$) was observed although overall nitrogen balance was similar for both diets. Mean rumen pH was similar for both treatments. VFA concentration (Acetate, Butyrate, Propionate, Total. mmol/l) was greater ($P < 0.05$) in the MBLF treatment.

Conclusions
The inclusion of MBLF in the diet as a replacement for concentrate feed maintained levels of production increased milk fat concentration and enhanced rumen fermentation without negatively affecting diet digestibility, nitrogen balance or methane production.

Acknowledgments
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091

Analysing the pattern of methane emissions from the nostrils and mouth of dairy cows

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Application
This study will aid in bridging the knowledge gaps in cattle physiology and methane emissions, while also providing useful findings for research into improving mitigation strategies in the livestock sector.

Introduction
Cattle contribute greatly to global methane emissions as a result of enteric fermentation. In respiration chambers, it is established that the majority of methane is released through the mouth and nose of the animals through eructations and only a small percentage is released through flatulence (Liu et al., 2021). To date there have been no studies to determine whether the emissions originate from the nostrils or the mouth of cattle. Cattle are obligate nasal breathing species and it is expected that the methane is released through their nostrils under normal conditions. Exceptions to this only occur if there is a nasal obstruction or the animal is experiencing heat stress. Therefore, this study was designed to measure and compare the methane emissions from the mouth and the nose of dairy cows.

Materials and methods
This study used two separate devices to measure methane concentration, flow, pressure, temperature, and humidity in each exhaled breath. One device (A) was used to measure the amount of methane exhaled from the mouth and the nose simultaneously while the second device (B), was designed to measure the amount of methane exhaled only from the nose of the cows. Device A was an adapted equine nebuliser and device B was a unique mask that only covered the nostrils of the cows made from a soft silicone. Both of the devices were connected to a tube (about 1m long) with a sensor box at the end. The measurements were collected at three time points using one Holstein Friesian cow per day from the same herd. Each device collected data for a total of 10 minutes starting with device A, then B. The data was analysed for each cow and each device separately.

Results
Device A showed a methane concentration of 4544 ppm at an average peak flow-rate of 273.85 lpm (litres per minute) while device B (nose only) averaged 3439 ppm at an average peak flow-rate of 221 lpm. The average humidity for both devices was 95% and an average temperature of 30 °C. The data also showed clear peaks in methane concentration followed by a slow decline in concentration values until another peak was seen.

Conclusions
Using this data it is possible to conclude that the majority of the methane emitted is released through the nostrils of the dairy cows, however, more work on this is required across varied cattle breeds, ages, different management systems (i.e. diet and production stages). This study will aid in bridging the knowledge gaps in cattle physiology and methane emissions, while also providing useful findings for research into improving mitigation strategies in livestock.

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092

Dose response effects of *Himanthalia elongata*, *Chondrus crispus*, *Alaria esculenta* and *Fucus vesiculosus* macroalgae on *in vitro* rumen fermentation and methane production compared against *Asparagopsis taxiformis*

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Application
The dietary provision of some brown macroalga have been shown to reduce enteric methane (CH_4) expelled from ruminants *in vitro* at high dose rates whilst when included at >8% the response is non-significant. The mechanism for reducing CH_4 may be due to phenolic compounds, specifically phlorotannin's found exclusively in brown seaweeds. Iodine in seaweeds may also enrich food products destined for the human food chain.

Introduction
Several macroalga (seaweed) species were assessed *in vitro* for their effects on rumen fermentation and subsequent CH_4 mitigation. Existing research highlights *Asparagopsis taxiformis* as a potent inhibitor of CH_4 in *in vitro* and animal studies with reported reductions in CH_4 emissions of 99% observed *in vitro* (Machado et al., 2016) and 80% observed *in vivo* (Roque, 2021). However, there are fewer studies investigating the potential of brown macroalgae on CH_4 emissions. We assessed the brown seaweeds *Himanthalia elongata*, *Chondrus crispus*, *Alaria esculenta* and *Fucus vesiculosus* for their CH_4 mitigating potential using rumen fermentation *in vitro* experiments to screen selected macroalgae and *A. taxiformis* for CH_4 and ammonia mitigating abilities.

Materials and methods
Dried perennial ryegrass silage (sourced from AFBI Hillsborough) and/or brown macroalgae (provided by Teagasc Ashtown) were used as substrates. Rumen contents ($n = 3$) were strained through four layers of cheesecloth and mixed with a buffer solution (Goering and Van Soest, 1970) in a 50:50 ratio (vol/vol) at 39 °C under continuous flushing with CO_2. Macroalgae were included at three dose levels; 4%, 6% or 8% and the silage content was adjusted accordingly with 1.60g being the 0% negative control. 100ml Wheaton glass serum bottles were used as the incubation vessels with each containing 60ml of the buffered rumen fluid.
At every time-point (0h, 4h, 24h and 48h), three biological replicates were included per treatment. At all time-points pH was recorded and a 1.5ml sample was taken from each bottle and centrifuged (4 °C, 20G, 10 minutes). At the 4h, 24h and 48h timepoints gas was collected from the bottle headspace for CH_4 measurements with a FID detector, calibrated by six levels of pure CH_4 (10–100 μL). Ammonia quantification was carried out according to the method of Chaney and Marbach (1962).
The homogeneity and normality of the data sets were assessed before the completion of two-way ANOVA analysis with Bonferroni post-hoc tests performed at each time point.

Results
At all timepoints and inclusion levels no significant ($P > 0.05$) differences were observed between the 0% control and brown macroalgae for CH_4 production with the exception of *Chondrus crispus* included at 6% of DMI. At the 24 h time-point, a significant increase in methane production over the control was observed ($P < 0.01$). *A. taxiformis* significantly reduced CH_4 production at all time-points and inclusion levels ($P < 0.05$) by between 91% and 96%. None of the included treatments had a significant effect on ammonia production ($P > 0.05$).

Conclusions
The *in vitro* inclusion of *A. taxiformis* at all tested inclusion levels has the ability to significantly reduce methane production whereas the inclusion of *Himanthalia elongata*, *Alaria esculenta* and *Fucus vesiculosus* showed no response, and *Chondrus crispus* at the medium inclusion increased methane. Additional research needs to be carried out on the bioactive compounds involved and quantity required for consistent and substantial CH_4 reduction.

Acknowledgments
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093

An investigation into factors influencing nitrogen use efficiency on commercial dairy farms

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Application
Milk yield and starch intake were positive drivers of nitrogen use efficiency on farm, although relationships were weak.

Introduction
Dietary protein is used inefficiently by dairy cows, with approximately 75% of nitrogen (N) consumed excreted as manure. Given the concerns about the environmental impact of N losses (nitrates to water and ammonia and nitrous oxide to the atmosphere), there is considerable interest in improving N use efficiency (NUE) on dairy farms. This study was undertaken to quantify NUE during the winter on commercial dairy farms within Northern Ireland and to identify production and dietary parameters which impact on NUE.

Materials and methods
This study was conducted on 26 dairy farms during winter 2018/19 and involved 3,547 early lactation cows. Data was collected for months two to five of lactation when all cows were housed. Each farm was enrolled in a milk recording scheme which provided monthly test-day milk yield and milk composition data. Information on concentrate intakes for each cow during the week prior to milk recording was obtained, either from automated concentrate feeding systems, or calculated using information on feeding practices on each farm at that time. Concentrates were offered on a feed-to-yield basis on all farms. A sample of each forage type and each concentrate type being offered was taken every 6–8 weeks and analysed for N, starch (concentrates only) and metabolizable energy (forages only) content. Individual cow intakes were determined as per Shirali et al. (2020). Individual cow data for each farm was averaged over months 2–5 of lactation and responses were examined using simple linear regressions.

Results
Average daily milk yield, daily concentrate dry matter intake (DMI) and NUE on the farms over the four month period was 34.4 kg (range: 28.8–41.1 kg), 10.4 (range: 8.2–12.9 kg) and 30% (range: 26–34%), respectively. Positive linear relationships were found between NUE and milk yield, concentrate DMI, total starch intake and total metabolizable energy intake with an r^2 of 49%, 17%, 47% and 21% respectively. Total diet crude protein level was negatively related to NUE (r^2 = 29%).

Conclusions
Average NUE during early lactation was 30%. As total diet crude protein level increased, NUE decreased. However, relationships between NUE and milk yield, concentrate intake, total diet crude protein level, total starch intake and total metabolizable energy intake were relatively weak.

Acknowledgments
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094

Using attention neural networks to estimate individual-level pig growth trajectories from group-level weight time series

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Application
Increasing the accuracy of models that predict individual-level pig growth trajectories as an improved cheaper alternative to using radio-frequency identification tagging systems.

Introduction
Machine learning methods can be used to estimate individual-level pig growth trajectories as a cheaper alternative to using radio-frequency identification tag systems (Taylor et al., 2022). However, the use of traditional machine learning methods in this task has several limitations, namely that they cannot incorporate all data on a group-level time series simultaneously. This limitation could have a potentially profound impact on their predictive accuracy and thus also their applicability. In this study, we explored whether deep learning models could be used as an improved alternative for predicting individual-level growth trajectories.

Materials and methods
A dataset consisting of time series liveweight data for 424 grower-finisher pigs was obtained from our university's commercial farm. The data was used to simulate 6000 unique group-level scenarios using different combinations of pigs and different sampling rates of measurements. Attention neural networks were trained using these group-level scenarios to predict the likelihood of each pair of pig weightings belonging to the same pig. Likelihoods were then clustered using agglomerative clustering to predict a pre-defined number of individual-level growth trajectories. The predicted trajectories were matched to the true trajectories, and the average of root mean squared error scores across trajectories was computed. Comparisons were made between the performance of random forest, gradient boosting, support-vector machine, and multi-layer perceptron models versus the attention neural network model across scenarios. To evaluate the usefulness of the inferred growth trajectories, two-week weight growth forecast models were trained to compare the use of predicted growth trajectories to using tagged data as input to such models.

Results
When predicting growth trajectories, the attention neural network achieved an average root mean squared error score of 1.59 Kg per pig across all scenarios versus the best performing traditional machine learning model – Random Forest – which scored 2.26 Kg per pig. In the downstream growth prediction task, the attention neural network scored 2.83 Kg on average versus 2.56 Kg scored by the Random Forest model. This is in comparison to a score of 1.74 Kg when using tagged trajectories directly.

Conclusions
Attention neural networks can be used to increase the accuracy of estimated individual-level pig growth trajectories thus creating an improved alternative to using expensive tagging systems. However, models that used growth trajectories predicted by the neural network model were outperformed by the models that utilised Random Forest trajectories and therefore require further improvement (e.g. fine-tuning) for this specific task.

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Reference

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095

Can increasing feeder space reduce damaging behaviour in pigs?

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Application
Doubling feeder space from 1 to 2 spaces/12 pigs did not reduce damaging behaviour at pen level, but positively impacted animal performance and carcass quality at slaughter.

Introduction
Tail-biting is one of the most challenging welfare problems in commercial pig production, with lack of access to high-priority resources considered a major risk factor. This study investigated whether increasing feeder space from single (1 feed-space: 12 pigs) to double spaced (1 feed-space: 6 pigs) feeders could help to reduce performance of damaging behaviours, lesions to tails and ears, and improve production performance, in a typical commercial pig system.

Materials and methods
Undocked (n = 288) pigs were weaned in their litter groups (8.6±1.49kg) and randomly assigned to one of 24 pens (n = 12 pigs/pen), a double spaced feeder (DOUBLE, n = 12 pens) or with a single-spaced feeder (SINGLE, n = 12 pens) until slaughter age. Pens were equipped with a rack of fresh grass and a rubber toy (weaning phase) or a wooden board (finishing phase). Every 2 weeks, pens were directly observed using all occurrence behaviour recording for 5 minutes, 4 times a day. All instances where pigs interacted with the enrichment and engaged in aggressive (head-butting, biting, fighting) and harmful (tail or ear biting and belly noising) behaviour were recorded. Additionally, pigs were individually assessed every 2 weeks for ear, tail and flank injuries using a 4-point scale (0 = no injury, 3 = severe injury). Individual body weight was recorded at weaning, transfer and slaughter, and feed delivery recorded daily at pen level; from these measurements, average daily gain (ADG), feed intake (ADFI) and feed conversion ratio (FCR) were calculated. Data were analysed using SAS v9.4. [RMD (1] [KO2] [RMD(3] A general linear model (Proc Mixed) and a generalised linear mixed model (Proc Glimmix) were used accordingly. Treatment, recording day (where repeated measures were used), and the interaction between these and replicate [RMD(4] were used as a fixed effect. Unless specified, the pen was considered the experimental unit.

Results
There was no effect of treatment on damaging (SINGLE = 0.39 ± 0.025, DOUBLE = 0.41 ± 0.024, instances/pig/min) or aggressive (SINGLE = 0.51 ± 0.03, DOUBLE = 0.49 ± 0.03, instances/pig/min behaviours, or interaction with the enrichment. Pigs in DOUBLE had worse tail lesion scores on 6 of the 9 recording days (P < 0.001), but values rarely exceeded 1 (Length, n = 15, Damage, n = 75, Freshness, n = 78 instances; 2503 recordings). Although both treatments had a similar live-weight at slaughter and cold-carcass weight FCR was lower in DOUBLE than SINGLE (1.53 ± 0.02 vs 1.62 ± 0.03; g/g, P < 0.05). Lean meat percentage was higher in SINGLE than DOUBLE (59.01 ± 0.165 vs 58.52 ± 0.160; P < 0.05).

Conclusions
These data suggest that doubling space at the feeder to two spaces/12 pigs did not influence overall levels of damaging or aggressive behaviour, including tail-biting behaviour relative to pens with the standard feeder. Nevertheless, increasing feeder space could lead to better feed efficiency and carcass quality at slaughter.

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096

Dehulled faba beans for weaner pigs

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Application
Dehulled faba beans might improve gut health in weaner pigs.

Introduction
Faba beans can completely replace soya bean meal in growing and finishing pigs (Houdijk et al., 2013). However, its use in weaner pigs is thought to be more constrained by antinutritional factors, especially those residing in the hulls. Indeed, dehulling increases faba bean ileal amino acid digestibility in broilers (Houdijk et al., 2021). Here, we tested different levels of dehulled faba beans (DHFB) in weaner pigs.

Materials and methods
A standard weaner ration was mixed with an experimental combination of DHFB, soya oil, amino acids, mineral and vitamins, to obtain six iso-energetic and iso-nitrogenous meals with 0 (control), 7, 14, 21, 28 and 35% DHFB. These were fed for 14 days to 108 newly weaned pigs, housed in 36 pens of 3 pigs each (n = 6 pens per treatment), with initial mean body weight of 8.1 ± 0.07 kg. We measured feed intake daily, body weight twice weekly and apparent total tract nutrient and energy digestibility through faecal grab sampling over the last three days and using TiO_2 as digestibility marker. Data was analysed through ANOVA, using three orthogonal contrasts to assess DHFB presence, linear or quadratic effects.

Results
Compared to control, DHFB fed pigs weighed less at trial end (12.2 vs 11.0 kg; s.e.d. 0.52; P = 0.006) and during the second week ate less (536 vs 442 g/d; s.e.d. 46 g/d; P = 0.013) at similar feed conversion ratio (1.29 ± 0.10), with no DHFB level effects (P>0.30). DHFB feeding per se did not affect dry matter, crude protein and gross energy digestibility (P > 0.15), averaging 85.2 ± 0.30, 80.2 ± 0.48 and 85.0 ± 0.34%, respectively, though all linearly decreased with increased DHFB level (P = 0.064, 0.034 and 0.081, respectively). However, DHFB feeding

increased neutral detergent fibre digestibility from 42.8% to 57.7% (s.e.d. 3.6%, $P < 0.001$), which linearly increased with DHFB level ($P = 0.058$).

Conclusions
Observed effects of DHFB per se on performance with no inclusion level effects suggest its nutritional value was overestimated. Pending data on ileal amino acid digestibility is expected to account for this. The combination of reduced faecal crude protein and increased faecal fibre digestibility at similar growth performance when DHFB were fed supports the view that excess protein is lost via the faeces rather than the urine, which is indicative of improved gut health.

Acknowledgments
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097

Moist pressed sugar beet pulp increases performance during gestation and lactation in sows housed outdoors

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Application
Dietary pressed sugar beet pulp may improve the performance of pregnant and lactating sows.

Introduction
Sugar beet pulp (SBP) supplementation of sows during gestation may increase satiety and increase subsequent feed intake during lactation. However, drying SBP is energetically costly, so there is a potential to save energy by mechanically pressing SBP without heating. Therefore, this study was conducted to determine whether pressed SBP (PSBP) could benefit gestation and lactating sows.

Materials and methods
Sixty-four sows (14 primiparous and 50 multiparous sows) housed outdoors were allocated to a $2 \times 2 \times 2$ factorial design with the factors being gestation diet, lactation diet and parity. The gestation diets were either a commercial compound feed or an isocaloric (net energy basis) and isonitrogenous (standardized ileal digestible lysine basis) mix of balancer feed and PSBP (ca. 28% dry matter) in a total mixed ration (TMR) (ca. 38:62 as-fed basis) offered from day 30 of gestation. After farrowing, the dams from each dietary gestation group were split into two groups that were fed either a compound feed or a TMR of balancer compound feed and PSBP (ca. 74:26 as-fed basis) ad libitum until weaning.

Results
There were no effects of PSBP on total born ($p = 0.40$), born alive ($p = 0.50$), litter weight (0.19), litter weight born alive ($p = 0.26$), birth weight ($p = 0.76$), and born alive birth weight ($p = 0.90$) across all dams. However, when the gilt data were analysed alone, feeding PSBP during gestation increased birth weight (1.44 vs 1.57 kg, $p = 0.036$). Dams that consumed PSBP during gestation tended to have heavier litter (88.5 vs 102 kg, $p = 0.067$) and piglet (8.39 vs 8.79 kg, $p = 0.047$) weights at weaning and reared more piglets to weaning (10.6 vs 12.1 piglets, $p = 0.030$) than those that consumed a control diet. However, there was an interaction such that PSBP during lactation decreased the number of piglets weaned in those dams that consumed the control diet in gestation (11.5 vs 9.8 piglets), whereas it was increased in those that consumed PSBP in both stages (11.5 vs 12.7 piglets). Dams that consumed PSBP during gestation had litters with lower post-foster mortality (16.8 vs 9.5%, $\chi^2 = 9.32$, $p = 0.002$) as well as pre-weaning mortality (20.5 vs 11.7%, $\chi^2 = 12.1$, $p < 0.001$).

Conclusions
The major finding from this study was that sows consumed a gestation diet containing over 60% fresh weight of PSBP with positive benefits. In particular, primiparous sows that consumed PSBP during gestation had increased average piglet birthweight. The most striking benefits were during lactation, where dams that had previously consumed PSBP during gestation had greater litter weights and number of piglets at weaning.

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098

Performance of the remaining finisher pigs following a split marketing event

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Application
Split marketing may improve the performance of the remaining pigs in the pen.

Introduction
Split marketing is a strategy often used where the heaviest pigs are removed from a pen and marketed before other pigs in the pen. This allows the lighter pigs extra time and access to resources to grow to the desired weight. The objective of this work was to evaluate marketing strategy, removing either 0% (representing the control group were all pigs in the pen were sent to market as a whole group the following week) or 50% of the heaviest pigs from the pen, on feed intake, growth performance, and feed efficiency of remaining pigs.

Materials and methods
At 87.5 ± 0.83 kg 16 pens of finisher pigs (Landrace × Large White dams × Danish Duroc boars) were allocated to one of 2 treatments; (1) split marketing group (SM), where the 50% heaviest pigs were removed for slaughter at day 14, and (2) control group, where all pigs remained in the pen until day 21. Feed intake and weights of individual pigs were determined using the Pig Performance Nedap ProSense system. Data were used to calculate performance 14 and 7 days prior to the split marketing (SM) event and the first 7 days after the split marketing event. A repeated measure was carried out excluding the 50% heaviest pigs (based on weight at the SM event) from all pens so that changes over time, before and after the split marketing event, of the lightest 50% of pigs in the pen could be compared.

Results
Feed intake increased at each time point ($P < 0.001$). Feed intake between the SM and control group was not different at 14 and 7 days prior to the SM event, however during the 7 days following the SM event, SM pigs had a higher feed intake (2.911 vs. 3.276 ± 0.074 kg/day; $P < 0.01$). Daily gain was reduced over time with gain over the 7 days post the SM event being lower than gain at 14 and 7 days prior to the SM event (1.039, 0.981 and 0.872 ± 0.057; $P < 0.05$). Feed conversion ratio (FCR) increased at each time point ($P < 0.001$). The number of feeder visits per day increased each week ($P < 0.001$) with the number of visits being higher for the SM group compared to the control group following the SM event (12.1 vs. 9.9 ± 0.499; $P < 0.001$). However the length per visit (seconds) was lower for SM pigs compared to control pigs after the SM event (356.6 vs. 426.5 ± 30.747; $P < 0.05$).

Conclusions
Split marketing of finisher pigs had no negative effect on performance of remaining pigs. Feed intake and number of feeder visits of remaining pigs increased, suggesting they had easier access to resources once heavier pigs had been removed.

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099

How pig behaviour influences Feed Conversion Ratio (FCR)

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Application
Understanding of the factors which may or may not influence the feed conversion ratio (FCR) of pigs can be used to improve productivity.

Introduction
Electronic feeders can provide access to large amounts of data relating to the feeding behaviour of pigs, which can help identify the factors which influence feed intake, performance and feed efficiency. Behaviours such as feeding rate have been correlated with improved performance characteristics e.g. feed intake, growth rate (Fornós et al., 2022). The aim of this work was to use information gathered from electronic feeders to determine if certain behaviours can influence the feed conversion ratio (FCR) of finisher pigs.

Materials and methods
Behavioural data was obtained from 319 finisher pigs across four experimental studies conducted at AFBI Hillsborough Northern Ireland. Pigs were housed in mixed sex pens of (8–10 pigs/pen) from 12 weeks of age (42 ± 5.7kg) through to slaughter at 22 weeks of age (100 ± 9.9kg). Each pen was equipped with a single-spaced, MLP FIRE feeder which provided finisher diets formulated to BSAS (2003) specifications. Feeders recorded the number of visits per day (NVD), average time spent in feeder per visit (min) (TPV) and the total time spent in feeder per day (min) (TTF) for individual pigs. Correlations between each of the behavioural traits and FCR were performed using R version 3.6.3.

Results
The average FCR of pigs across all experiments was 2.55 (SD 0.24). The number of visits to the feeder ranged from 4 to 47, with a mean of 11 (SD 6) visits per day. While the average time spent per visit was 6 min (SD 3), time ranged from 1 to 19 minutes. The total time spent at the feeder per day averaged 59 min (SD 15), with a large variation observed between individuals, ranging from 31 to 152 minutes per day. No significant relationships were found between FCR and NVD ($y = 0.0025x + 2.5136$, $R^2 = 0.0032$, $P = 0.117$), TPV ($y = 0.0151x + 2.4446$, $R^2 = 0.0248$, $P = 0.109$) or TTF ($y = 0.0027x + 2.3822$, $R^2 = 0.0236$, $P = 0.732$).

Conclusions
Feeding behaviour was highly variable between individuals. The NVD, TPV and TTF does not appear to influence FCR. This lack of effect suggests that interactions with or time engaged with the feeder is not necessarily reflective of feed intake. However, it would be of interest to focus in on specific periods of production to gain a better understanding of the effects of diet changes and age on feeding behaviour and their impact on FCR.

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100

Identification of genetic polymorphisms in MC4R and GPX5 genes in the autochthonous Greek black pig breed

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Application
The autochthonous Greek black pig breed, which was raised locally and is well known for the high quality of its meat, is the only traditional indigenous pig breed reared in Greece and is able to adapt to different and harsh environmental conditions.

Introduction
Recent studies have reported that gene polymorphisms in melanocortin 4 receptor (MC4R) and glutathione peroxidase 5 (GPX5) genes are associated with litter size in pig and can be used as genetic markers in gene assisted selection programs for the improvement of reproductive performance. The objective of this study was to investigate the existence of these polymorphisms in the autochthonous Greek black pig breed.

Materials and methods
One hundred sixty pigs raised in Greece were included in the study. DNA was extracted and genotyping was performed using RFLP – PCR.

Results
The molecular results showed that for MC4R, genotype GG had a frequency of 0.37, GA 0.44 and AA 0.19, while the frequency of allele G was 0.56 and of A 0.44. For GPX5, genotype AA had a frequency of 0.19, AB 0.41 and BB 0.40, with frequencies of alleles A and B being 0.43 and 0.57, respectively.

Conclusions
These data revealed that all genotypes of the two genes were present in the investigated population, indicating that these genes could be used for Marker-assisted selection programmes for the genetic improvement of reproductive characteristics of this breed.

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101

The capacity of inspection on farm and at the abattoir to predict post-mortem outcomes in slaughter pigs: A study at animal level

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Application
To discover the association between the presence of these animal-based welfare outcomes at ante-mortem (AM) inspection (both on farm and at the abattoir) and PM inspection outcomes is useful to address the organization of official controls in abattoirs.

Introduction
The aim of this study was to investigate associations between ear, tail and skin lesions, hernias, bursitis and rectal prolapses at the abattoir and meat inspection outcomes in slaughter pigs, including carcass condemnations and trimmings, carcass weight and carcass quality.

Materials and methods
This was an observational study whereby pigs were managed according to routine practices in a single abattoir. Data were collected from 1816 pigs. The relationship between animal-based welfare and post-mortem outcomes were analysed using generalised mixed models (Proc Glimmix).

Results
Our findings showed that tail lesions were associated with entire carcass condemnations and trimmings $P < 0.001$), a reduction in carcass weight ($P < 0.05$) and a potential to impair carcass quality by reducing muscle pH ($P < 0.05$), especially in carcasses from male pigs ($P < 0.05$). Additionally, hernias were associated with viscera condemnation ($P < 0.05$) and a reduction in carcass weight ($P < 0.05$).

Conclusions
Our findings confirm that ante-mortem inspection could be useful to predict post-mortem outcomes in the same pigs, especially in cases of tail lesions and hernia, which might trigger attention of the veterinary inspector in charge of the post-mortem inspection.

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102

Effects of dietary soluble and insoluble fibre on the different forms of waste nitrogen and phosphorus in an in vitro pig gut model

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Application
Use feed ingredients, such as dietary fibre type, to modify forms of faecal nitrogen (N) and phosphorus (P) to suit to its end-use, thereby adding to its value and lessening its environmental impact.

Introduction
Feed ingredients are primary determinants of faecal nutrient composition. There has been considerable research effort to maximise nutrient digestibility and retention and thereby reduce the concentration of nutrients, N and P in particular, in animal excreta for obvious economic and environmental reasons. Feed ingredients also affect the forms of excreted N and P. For example, dietary fibre effects the forms of excreted N, ammonia in particular (Trabue et al., 2022). The aim of this study was to determine the effect of dietary fibre, both soluble and insoluble, on the excreted forms of both N and P using an in vitro model of the pig gut.

Materials and methods
The pig gut model of Palowski et al. (2021) was employed to test four treatment diets, each in quadruplicate: control (CO; commercial pig grower feed), control plus 5% inulin (IN; soluble fibre), control plus 5% cellulose (CE; insoluble fibre), and control plus 10% sugar beet pulp (SBP). Fermentation fluid was analysed for ammonia-N (NH3-N), total Kjeldahl-N (TKN), nitrate (NO3-), nitrite (NO2-), total P (TP), and inorganic P (Pi). Organic P (Po) was calculated as TP minus Pi, total organic N (TON) as TKN plus NH3-N, and total inorganic N (TIN) as NO3- plus NO2-. Data were analysed by GLM (SPSS 26). Treatment effects were considered significant at $P < 0.05$.

Results
For waste N, while there were no differences between fibre types for TIN:TN, all fibre diets when compared to the CO diet reduced the proportion of TIN:TN (average 50%, $P < 0.05$), due to their reduction ($P < 0.05$) of NH3-N:TN, and increased the proportion of TON:TN (average 106%, $P < 0.05$). For waste P, the IN diet increased ($P < 0.05$) the Pi:TP compared to the CO and SBP diets by 142 and 43% respectively. While there were no differences between fibre types for Po:TP, all three fibre diets reduced the Po:TP compared to the CO diet (average 62%, $P < 0.05$).

Conclusions
Dietary fibre and type of dietary fibre influenced the forms of waste N and P exiting from an in vitro model of the pig gut.

Acknowledgments
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103

Optimising liquid feeding system hygiene to improve the microbiological quality of liquid feed for grow-finisher pigs

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Application
No standard guidelines exist for optimising liquid feeding system hygiene, and current practices vary considerably between farms. This study examines the possibility of providing pig farmers with a protocol for improving liquid feeding system hygiene.

Introduction
Uncontrolled fermentation in liquid feed leads to the proliferation of undesirable microbes, with a subsequent loss of energy and amino acids from the diet (O'Meara et al., 2020). Our objectives were to perform an intensive physical and chemical cleaning protocol on the feeding system to disrupt microbial biofilms, suppress *Enterobacteriaceae* and fungal growth, and maintain system hygiene.

Materials and methods
Baseline samples were collected before the start of the trial. An intensive physical and alkaline detergent cleaning, followed by an acid wash, was performed on the feeding system. Thereafter, an acid rinse of the system was conducted nightly during the 76-day feeding study. This rinse residue was used to prepare the first feed of each day. On day (d)1 post-cleaning, 180 pigs (35.0 kg ± 4.90 SD) were sorted by weight into pen groups of 5 pigs each (36 pens in total) and liquid-fed from the system. At each of 13 sampling occasions during the study, swabs from the mixing tank and inside the feed pipe were collected, along with feed samples from the mixing tank and troughs, for microbiological and physicochemical analysis. Scanning electron microscopy (SEM) was also performed on internal pipe surfaces.

Results
Enterobacteriaceae, yeasts and moulds were undetectable during the d1-week (wk)1 post-cleaning period on the mixing tank and pipe surfaces, compared to baseline. However, yeasts and moulds were still detected in the pipes at d1 post-cleaning, but were undetectable by d3. This finding was confirmed by SEM images showing damaged fungal hyphae in the pipes on d1 post-cleaning, which were absent thereafter. Yeasts and moulds remained undetectable on the mixing tank surface up to wk4 post-cleaning, while *Enterobacteriaceae* and moulds were undetectable in the pipes until wk10 post-cleaning. By wk5 post-cleaning, *Enterobacteriaceae*, lactic acid bacteria and yeasts had returned to baseline levels on the mixing tank surface. Microbial counts and pH of the feed were not impacted by the cleaning protocol.

Conclusions
An intensive cleaning protocol improved liquid feeding system hygiene, while feed microbiology was not impacted. Direct acidification of feed or microbial inoculants may be required to improve the microbial quality of liquid feed.

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104

Peracetic acid to replace zinc oxide, modulating microbiota to control pig post-weaning diarrhoea

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Application
In-water peracetic acid (PAA, CH_3CO_3H), derived by the hydrolysis of sodium percarbonate (SP) and tetraacetylenediamine (TAED) could replace zinc oxide (ZnO), controlling pig post-weaning diarrhoea via microbiota modulations.

Introduction
ZnO has been widely used to alleviate weaning-diarrhoea symptoms (Ou et al., 2007), however it has recently faced a ban due to environmental pollution. SP/TAED-derived in-water PAA is a broad-spectrum antimicrobial-alternative with proven efficacy in poultry (Galgano et al., 2021). In this study, we tested the PAA potential towards post-weaning diarrhoea compared to ZnO.

Materials and methods
Four treatments, control, in-feed ZnO (3100 ppm), 50 ppm and 150 ppm of PAA, were administered to 6 pens/treatment (14-day trial) with 2 pigs per pen and 6 rooms (4 pens/room). In-water PAA treatments were prepared daily, mixing different ratios of SP and TAED. We measured faecal scores/performance, and microbial composition via 16S rRNA sequencing (515Fb-816Rb) of DNA from stomach, ileum and caecum. Linear mixed model was carried out in R with lme4 for performance and MaAsLin2 for taxonomical data, including fixed (treatment) and random effects (rooms/pens/pigs), β-diversity was analysed via PERMANOVA.

Results
Lower faecal score, linked to improved diarrhoea was found in the ZnO group at day-7 (1.26 ± 0.2) compared to control (1.52 ± 0.1, $P < 0.05$), whilst day-14 diarrhoea improved in 150 ppm (1.57 ± 0.44, $P = 0.05$), ZnO and 50 ppm (1.36 ± 0.26 1.57 ± 0.31, $P < 0.05$) compared to control (1.8 ± 0.37).
Bray-Curtis dissimilarity analysis showed different caecal microbial composition in the control group, compared to 50 ppm, 150 ppm and ZnO ($P < 0.05$, $Q < 0.05$). The same analysis showed that 50 ppm and 150 ppm had similar caecal composition, which was however different from ZnO ($P < 0.05$, $Q < 0.05$). Stomach *Campylobacter* was reduced in 150 ppm, ZnO ($P < 0.05$, $Q < 0.05$), and 50 ppm ($P < 0.05$, $Q = 0.161$) compared to control. ∼20 caecal genera were differentially abundant, e.g., *Ruminococcus*, *Oribacterium* reduced were in ZnO compared to control ($P < 0.05$, $Q < 0.05$).

Conclusions
We found that both PAA and ZnO improved the faecal scores. PAA and ZnO reduced stomach *Campylobacter*, linked to post-weaning diarrhoea (Adhikari et al., 2019). *Ruminococcus* and *Oribacterium*, linked with better performance (Uryu et al., 2020) were only reduced in ZnO.

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105

Comparing a seaweed blend to zinc oxide in weaner pig diets: The effect on performance and gut health

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Application
Seaweed blend has potential to improve performance in ZnO-free diets.

Introduction
After the ban of pharmacological zinc oxide (ZnO) in EU pig diets, alternatives to improve performance and health of pigs post-weaning are being sought. Seaweed blends are of interest, with potential prebiotic effects. This work compared two levels of OceanFeed Swine, to low and high ZnO diets, on feed intake, growth, feed efficiency and gut health.

Materials and methods
240 pigs ((Large white × landrace) × Danish duroc)) were weaned (8.5 ± 0.31 kg) into pens of five pigs, balanced for weight and gender. Pigs were fed either: 1) positive control(PC)- standard diet with 3100 mg/kg Zn; 2) negative control(NC)- standard diet with 150 mg/kg

Zn; 3) NC+5 g/kg OceanFeedSwine (OFS); 4) NC+10 g/kg OFS, across three phases: days 0-7, 7-20, 20-42 post-weaning. Feed refusals per pen and individual pig weights were recorded at days 7,20,42 to determine average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) per phase. On day 20, six pigs per treatment were euthanized under Schedule 1 and dissected. Peripheral blood was collected for ELISA analysis of Interleukin-6 (IL-6), IL-1β and IL-10. Ileal mucosa was scraped for qPCR analysis of IL6, IL1β and tumour necrosis factor-alpha (TNF-α). A general linear model was used to analyse performance and ELISA data (SPSS, v26), with pen and individual pig as experimental unit, respectively. qPCR data were analysed in qbase+ and SPSS using a one-way ANOVA.

Results
Between 0-7 days, PC pigs tended to have higher ADG than other treatments ($P = 0.072$) and lower FCR compared to NC and NC+5 g/kg OFS (1.14, 1.52, 1.35 respectively; $P < 0.001$). Between 8-20 days, PC pigs tended to have higher ADFI than all treatments ($P = 0.061$). Feed intake for OFS at 5 g/kg or 10 g/kg was intermediate compared to PC and NC (0.409, 0.370, 0.440, 0.363 kg/day, respectively). ADG between 8-20 days was similar for PC and NC+5 g/kg OFS pigs (0.386, 0.308 kg/day; $P > 0.05$) with PC pigs gaining more than NC and NC+10 g/kg OFS (0.386 vs 0.264, 0.265 kg/day, respectively; $P = 0.008$). FCR was lower for PC than NC+10 g/kg OFS pigs (1.19, 1.42; $P = 0.001$). Between 21-42 days, there were no differences in ADG or ADFI. PC and NC+5 g/kg pigs had similar FCR; higher than NC (1.33, 1.30 vs 1.25; $P = 0.004$). There were no differences in mRNA levels of IL-6, IL1β or TNFα. In plasma, PC and NC+5 g/kg OFS tended to give lower IL-6 compared to NC and NC+10 g/kg OFS (1.7, 1.1, 4.7, 5.0 pg/ml, respectively; $P = 0.066$).

Conclusions
A reduction in levels of IL-6 may contribute to the improvements in post-weaning performance observed in high ZnO and 5 g/kg OFS groups.

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106

Associations between ear loss and reproductive performance in sows: Potential long-term effects of ear necrosis

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Application
Ear necrosis (EN) is a growing welfare concern in young pigs. Associations between ear loss and reproductive performance in sows suggest a potential long-term impact of EN. There is a need for more research on EN. Meanwhile, efforts should focus on improving the housing and husbandry of young pigs to reduce ear biting and other risk factors for EN.

Introduction
Black, bloody, and necrotizing lesions on the upper pinna of weaner pigs ears characterizes EN. Although the lesions typically heal with age, necrotisation permanently disrupts the ear's integrity. Associations with pericarditis in slaughter pigs indicates that EN may provide an entry point for pathogens. Hence, replacement gilts affected by EN may have chronic inflammatory processes which could interfere with later reproduction. The aim of this study was to evaluate associations between ear loss in pregnant sows, biomarkers of inflammation and reproductive performance.

Materials and methods
Pregnant sows ($n = 240$, mean parity 2.4 ± 1.03) were scored for ear loss as part of a larger trial on sow welfare. The left and right ears were scored as: 0 = ear intact, 1 = minor disruption, 2 = 1/3 of the ear missing, 3 = ½ of the ear missing and 4 = entire ear missing. On day 79 of pregnancy, sows chewed on a sponge to collect saliva which was analysed for haptoglobin (alphaLISA technology, Interdisciplinary Laboratory of Clinical Analysis, Murcia, Spain). Associations between haptoglobin, numbers of piglets born alive (BA), dead (BD), mummified (MUM), total born (TB) and ear lesion scores (ELS) for the left and right ears and the sum of the ELS were analysed by regression analysis in SASv9.4 (PROC MIXED/GLIMMIX).

Results
Sixty-four per cent of sows suffered ear loss. More sows were affected (155 versus 101 sows) and ELS were higher for the left than the right ear (1 ± 0.9 vs. 0.5 ± 0.54; $P < 0.001$). There were no associations with haptoglobin ($P > 0.05$). There was a tendency for an association between the total ELS and BA ($P = 0.080$) and TB ($P = 0.066$). There was a significant negative association between the right ELS and MUM (Reg coefficient [SE]; −0.4 [0.21], $F_{1,229} = 4.14$; $P < 0.05$) while the significant association ($P < 0.001$) with the left ELS was positive for this variable (0.04 [0.12],$F_{1,229} = 12.2$; $P < 0.001$). There was also a tendency for an association between the left ELS and BA ($P = 0.058$) while the association with TB was significant (0.6 [0.25], $F_{1,229} = 6.56$; $P < 0.05$).

Conclusions
There were associations between the severity of EN the growing gilts experienced and their later reproductive performance but these were not consistently negative which could explain the lack of an apparent mediating role of Haptoglobin.

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107

Preliminary study on the Potential of Vernonia amygdalina leaf meal (VALM) in the management of piglets after weaning

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Application
VALM can replace zinc oxide and antibiotics use in the prevention of post weaning diarrhea (PWD) in piglets, without a reduction in growth.

Introduction
Post weaning period is a critical time for young animals due to separation from the mother, changes in the gut micro-flora and the immature immune system. PWD is a major threat to the swine industry with increasing demand for production without antibiotics. Piglets are typically weaned between 14–28 days (Holman et al., 2021). The occurrence of PWD in piglets is between 3–7 days after weaning and oral treatment with Colistin is usually employed. Vernonia amygdalina has been proven to have antibiotic, anti-parasitic and antiprotozoal effects (Erasto et al. 2006). The potential of VALM as a preventive measure to PWD was investigated in piglets weaned at 2 to 6 weeks.

Materials and methods
Fresh VA leaves were collected, cleaned, air-dried under shade; thereafter ground, placed in air tight containers and kept at room temperature until use. Piglets were weaned at 2, 3, 4, 5, or 6 weeks, randomly allotted to three treatment pens with three replicate piglets each. Treatment 1 group had 0g VALM/kg body weight/day, treatment 2, 1.2g VALM/kg body weight/day while treatment 3, 2.4g VALM/kg body weight/day. 45 piglets were used in the experiment. VALM was administered in 1 litre of clean water, offered in the mornings; if water with VALM finished, plain clean water was given, any leftovers were discarded next day and drinker washed before administering the day's dose. All piglets were crossbred, fed same commercial diet in equal portions twice a day and treatments lasted for 7 days. Piglets were monitored for loose stools as a sign of PWD during and after the experimental period for up to 8 weeks from birth. Weight of piglets at birth, at weaning and after the experimental period were taken, feed and water intake were also recorded for the experimental period.

Results
All piglets given VALM did not have diarrhea throughout the experimental period and for up to 6, 5, 4, 3, or 2 weeks after VALM administration. Piglets on the control without VALM in drinking water had diarrhea on the 2nd, 4th and 5th day after weaning at 2, and 3 weeks respectively. Piglets given VALM had Faecal PH range of slightly acidic (6.7-6.9) compared to control piglets (7.1-7.3); VALM piglets consumed more water and less feed over the experimental period regardless of week at weaning.

Conclusions
VALM can be administered to weaned piglets at 1.2g or 2.4g/kg body weight per day. VALM shows high potential to prevent PWD with lasting effect for up to 6 weeks after 7 days administration.

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108

Effects of replacing zinc oxide with a combination of β-glucan, *Bacillus subtilis* PB6 and formic acid on the performance of weaner pigs

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Application
The combination of the β-1,3-glucan type immunomodulator and a probiotic (*Bacillus sp.* PB6) and formic acid appears to be an effective replacement for ZnO in diets of weaner piglets.

Introduction
inc oxide (ZnO) has been used at high doses in diets of pigs to reduce incidence and severity of post-weaning diarrhoea. In June 2022, the use of supra-nutritional levels of ZnO in pig diets was banned due to environmental pollution concerns. This study evaluated the efficacy of using a combination of additives, a β-1,3 -glucan, a *Bacillus sp.* PB6 and an encapsulated calcium formic and citric acid to replace ZnO in weaned piglets.

Materials and methods
Weaner piglets (380) were balanced for sex and weight then randomly allocated to two diets. The control group were offered a standard commercial pre-starter diet with ZnO (2500 ppm) on days 28-42, followed by a ZnO free starter diet on days 43-70. The treatment group, received a ZnO free pre-starter diet, with β-1,3 -glucan (Aleta^{TM}) (200 g/ton) + *Bacillus sp.* PB6 (CLOSTAT^{R}) (1000 g/ton) + encapsulated formic acid (Formyl^{TM}) (2 kg/ton) on days 28-42, followed by a starter diet with β-1,3 -glucan (200 g/ton) + *Bacillus sp.* PB6 (500 g/ton) on days 43-70. The trial was run in batches over three periods. In each run, 3 pens were allocated to each diet, replicated over 3 periods giving a total 9 pens per treatment. Body weights, piglet mortalities, faecal parameters (consistency scores, pH, dry matter) were measured. Data were analysed with One-Way ANOVA with batch used as block, using Genstat®.

Results
Postweaning piglet mortalities were low and similar on the two diets. Faecal parameters such as DM, consistency scores and pH were also similar. The additives used to replace ZnO resulted in similar liveweights and average daily gains (ADG) from days 28-42. At day 70, pigs on the ZnO free diet were heavier (29.8 kg) compared to those on standard diet (28.9 kg) (sed = 0.405, $P = 0.029$). ADG (g/day) for days 28-70, 42-70 and 56-70 were consistently higher in pigs on the ZnO free diet, than on the standard diet; with average values of 512 vs 490 (sed = 7.30, $P = 0.003$), 608 vs 560 (sed = 9.69, $P < 0.001$) and 678 vs 636 (sed = 14.89, $P = 0.006$), respectively.

Conclusions
The combination of additives used elicited comparable levels of performance in weaner pigs and in some cases exceeded the traditional ZnO based diet. The improvements in performance on the ZnO free diet translated into pigs that were approximately 1 kg heavier at day 70.

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109

A description of ear-directed and other damaging behaviour and ear lesions in weaned pigs

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Application
Increase the understanding of the etiology and risk factors of ear necrosis to improve pig health and welfare.

Introduction
Ear necrosis is a growing welfare concern that is characterized by black, bloody, and necrotizing lesions on the upper pinna of pig ears. However, the multifactorial etiology of ear necrosis is not well understood. One proposed theory describes ear biting as the root cause of ear necrosis whereby the trauma to the ears enables infection by bacteria and subsequently ear necrosis. Therefore, this study aimed to explore the prevalence of ear-directed behaviour and ear lesions in weaned pigs.

Materials and methods
Pigs (n = 275) were evaluated from April to August 2022 at the Teagasc Moorepark Pig Research Unit. On d 28 of age pigs were weaned, blocked by sex, weaning weight, and litter of origin and housed in 30 pens (single space feeders and plastic slatted floors) of 8-10 pigs. All occurrences of ear, tail and other (e.g. flank) directed behaviour were recorded live one day per week (weeks 2-6 post-weaning) during continuous 3 minute observations conducted twelve times per pen per day (0900 – 1600h). Ear lesions were scored (0 to 5 according to severity) weekly from week 1 to week 17 post-weaning. Hereafter, reference to ear lesions includes only those scored 3, 4 and 5 (i.e. moderate to severe lesions). Data were analyzed using SASv9.4.

Results
The highest frequency of ear-directed behaviour (0.57 bites per minute) was observed in pens of pigs at 3 weeks post-weaning, and performance of the behaviour decreased thereafter ($F_{4,87.3} = 14.87$, $P < 0.001$). This equates to 34 ear bites per hour in a pen of 8-10 weaner pigs. Ear biting was more prevalent than tail and other biting behaviour (i.e. flank biting) ($F_{2,178} = 141.90$, $P < 0.001$). Although there was no difference in performed ear biting between males and females, females performed more tail biting ($F_{1,38.5} = 4.83$, $P = 0.034$). Ear biting was associated with both tail ($P = 0.012$) and other ($P < 0.001$) biting. On the week when ear lesions were the most prevalent (i.e. week 6 post-weaning), 10% of all pigs were affected with one or more lesion. The most severe scores, score 5, were most prevalent in week 9 post-weaning, with 1.45% of all pigs affected.

Conclusions
Despite a high frequency of ear-directed behaviour during the weaner stage, the percentage of pigs affected by moderate to severe ear lesions was low. However, the time course of ear lesion development does not rule out ear directed behaviour as a causative factor. Clearly, other factors play a role in the etiology of ear necrosis. Pigs direct a high frequency of behaviours towards the ears and other body parts of their penmates reflecting compromised welfare in the weaner stage.

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110 (Invited Speaker)

Multifunctionality: A key element of a holistic UK sheep sector

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Farming sheep is a long established part of British agriculture, the value of which, until recent years, has been based on enterprise output. The sectors reputation as being dependant on subsidies and payments suggests that sheep farming is marginal in terms of profit capability, yet some 40% of sheep producers are ineligible for payments so either rely elsewhere for income, or run viable systems with tight control of costs and heightened productivity. The move away from the CAP towards a structure of reward for the provision of public good could be something that suits the sheep farming sector well. Sheep farming is increasingly being recognised as being 'holistic' and in most cases it fits the model of 'land sharing' (where land has shared outputs of food, fibre, environmental and social goods) rather than land sparing (where farmers and land managers focus on more singular outcomes dedicated for example to either production or nature). Yet we can't ignore the natural resource, climate, nature, and wellbeing challenges we face and if sheep farming is to be accepted and rewarded through the marketplace and the public purse then we have to demonstrate and evidence our deliverables as well as do more in certain areas.
This session will discuss what can be done with genetics and sheep breeding, health and parasite management, and nutrition, to reduce carbon footprints and improve productivity, as well as talk about the farmed environment and how it can be further enhanced in both grassland and arable regions to deliver multifunctional outcomes. We will aim to highlight the key important aspects of the sheep farming sector, discuss sheep related sustainability initiatives, and identify further research needs.

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111 (Invited Speaker)

Silvopasture as a sustainable sheep production system option

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In silvopastoral systems, trees are mixed with animals on the same unit of land and can deliver production and performance benefits and a range of ecosystem services resulting from significant ecological, environmental and economic interactions between the components. They are land use systems which are environmentally, economically and socially sustainable, and which have the potential to create resilience to predicted climate change impacts.
Evidence will be presented from a long-term silvopastoral agroforestry site established in Northern Ireland in 1989 to test three land use types – (1) a silvopastoral system with ash trees planted at 400 stems/ha and grazed by sheep, (2) permanent grassland also grazed by sheep (3) planted woodland with ash trees (2,500/ha). Sheep production was not reduced in the silvopasture until trees were 12 years old (c. 8 m ht & 15 cm diam) and subsequently recovered after tree thinning. Sheep performance was unaffected by the tree presence (Sibbald et al., 2001). From the measured evidence of animals seeking shade and shelter (Healey et al., 1998), individual animal performance benefits and resilience to climate extremes can be inferred.
It is proposed that silvopasture is more welfare-friendly than open pasture as : sheep have a more varied diet- access to tree fodder, are healthier – with extension of the grazing season animals have reduced incidence of respiratory diseases. Less tangible benefits but relevant, are the variation in habitat structure which may reduce "boredom". It is proposed that these benefits represent a significant marketing opportunity for sheep meat.
Soil zonal exploitation by roots led to greater water infiltration and reduced run - off for flood mitigation, earlier turn-out and later housing of livestock led to an extended grazing season and inferred. reduced ammonia emissions (McAdam, 2018) A range of biodiversity benefits were measured and carbon sequestration was estimated at 2.4 t/c/ha/yr. (Olave et al., 2016).
The Loughgall trial has been consistently managed since planting and is a unique resource to assess the long term impact of silvopastoral systems on a range of ecosystem services.

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112

The effect of the addition of a companion forage to a perennial ryegrass sward on ewe and lamb performance

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Application
The addition of clovers or herbs to grassland has the potential to improve animal performance in an intensive sheep grazing system.

Introduction
Multispecies swards including legumes, herbs and grasses have been shown to support increased sward and animal performance above that of a perennial ryegrass monoculture. Legumes provide nitrogen through biological nitrogen fixation, whilst herbs can provide improved drought tolerance and mineral content. Little however is known about how the elements of these mixtures perform individually under intensive sheep grazing. The objective of this study was to assess the influence of binary mixtures of perennial ryegrass plus one companion forage on ewe and lamb performance at pasture compared to a perennial ryegrass monoculture.

Materials and methods
Five sward mixtures were investigated, namely; i) perennial ryegrass (PRG), ii) PRG and white clover, iii) PRG and red clover, iv) PRG and plantain, and v) PRG and chicory. Five farmlets with one sward treatment assigned to each were established, stocked at 11.5 ewes/ha and

rotationally grazed by 23 Texel x Belclare ewes plus their lambs from March to December. The study was replicated in years 2018 to 2021. Annual companion forage content ranged from 9.6-14.7% on a dry matter basis. Lambs were weaned on average at 15 weeks of age. Lamb weight was measured fortnightly with lambs drafted at weights of 42-46 kg targeting a 20 kg carcass. Ewe weight and body condition score were measured at critical time points throughout the year namely; at mating, scanning, lambing, six weeks post-lambing and at weaning. Statistical analysis was carried out using a linear mixed model in PROC MIXED (SAS. Inst. Inc., Cary, NC).

Results
Results show increased lamb performance for all binary sward types, particularly in the post-weaning period, relative to PRG. Lambs grazing PRG and plantain, and PRG and red clover had 17–31 g/day higher lifetime average daily gain ($P < 0.01$), leading to 15.8–28.6 days lower average days to slaughter relative to PRG respectively ($P < 0.01$). PRG and white clover and PRG and chicory yielded intermediate levels of lamb performance. There was no difference in ewe weight or body condition score across sward types up until 6 weeks post-lambing however, some differences occurred thereafter.

Conclusions
Lamb performance was improved and ewe performance was maintained with the addition of a companion forage relative to a PRG sward. Binary sward mixtures have the potential to improve lamb performance leading to reduced days to slaughter from pasture under an intensive pasture based system.

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113

Implementation of Single-Step Genomic Evaluations approach on the national evaluation of Hill Sheep breeds

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Application
To improve the breeding schemes of sheep breeds by integrate genomic information in evaluating the genetic potential of the animals.

Introduction
The current widespread and growing use of DNA technologies in the livestock industry provides many opportunities for improving genetic programs and accelerating genetic progress. Within the context of hill sheep production, the costs of genotyping prevent the widespread implementation of genomic technologies in the whole population but are restricted to a subset of animals in the population. The Single-Step Genomic evaluation (SSGBLUP) is one of the most promising approaches to overcome this limitation and accommodate the current genomic information with all the recent and historical genealogical information, providing more complete data to evaluate the genetic potential of both genotyped and non-genotyped animals. This study aims to evaluate the impact of using genomic information and compare the prediction ability of SSGBLUP and pedigree-based genetic evaluation (PEDBLUP) using cross-validation techniques with the Linear Regression (LR) method.

Materials and methods
The dataset evaluated included 910,000 animals from 14 breeds (Welsh Mountain, Beulah, Scotch blackface, Roughfell, Herdwick, Hebridean, Hardy Speckle, South Wales Mountain, Swaledale, North Country Cheviot Park, North Country Cheviot Hill, South Country Cheviot, Black Welsh Mountain and Brecon Hill Chev). Among them, 43,070 animals were genotyped with different SNP arrays (e.g., Ovine_600K, AgR_Ovine_60Kplus, OvineSNP50, ARG_ovine_18K and Ovine_15Kv2) and all imputed to 53,401 SNPs using findhap.f90 V3 software. The analyses for both SSGBLUP and PEDBLUP with full and partial data were implemented in multiple trait model including 6 traits (fat depth (FD; 279,115), litter size born (LSB; 247,441), litter size reared (LSR; 247,441), muscle depth (MD; 279,392), lamb scan weight (SWT; 321,893), eight-week weight (W8W; 545,266)). The H-inverse was construed with Quaas-Pollak transformation using HGINV V1.03 program and MIX99 V22.0228 package was used for the analyses.

Results
For the focal animals (~3,350 genotypes) the prediction accuracy increased from 3.64 to up 15.52% when comparing SSGBLUP with PEDBLUP. The maximum increase corresponded to FD trait with an accuracy of 0.67 and 0.58 for SSGBLUP and PEDBLUP, respectively. The level bias reduced in SSGBLUP up to 0.31 and the dispersion bias reduced up to 0.04 in 5 traits (FD, LSB, LSR, MD, W8W).

Table 1. Accuracy, level and dispersion bias for pedigree and single-step genomic evaluation

Trait	Accuracy PEDBLUP	Accuracy SSGBLUP	Level Bias PEDBLUP	Level Bias SSGBLUP	Dispersion Bias PEDBLUP	Dispersion Bias SSGBLUP
Eight Week Weight	0.64	0.70	-0.09	-0.02	0.83	0.87
Fat Depth	0.58	0.67	-0.02	-0.03	1.04	0.99
Scan Weight	0.72	0.77	-0.55	-0.24	0.96	0.94
Muscle Depth	0.91	0.97	0.45	0.40	0.99	1.00
Litter Size Reared	0.55	0.57	0.00	0.00	0.93	0.95
Litter Size Born	0.56	0.61	0.00	0.00	0.98	0.99

Conclusions
The result of this study shows that SSGBLUP is a promising approach to integrate genomic information to improve the economically important traits in the Hill sheep breeds in Wales by increasing the prediction accuracy.

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114

Influence of slaughter season and sex on the instrumental colour and texture of commercial lamb chumps from a sample of PGI Welsh Lamb

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Application
This study forms part of a wider study into the factors that affect Welsh Lamb meat quality, to provide key information to the lamb industry, working towards developing a blueprint for the supply chain to consistently produce high quality lamb meat.

Introduction
As part of a wider study to understand factors that influence Welsh Lamb meat quality, seasonality and sex effects on instrumental texture and colour of lamb chumps were assessed using a targeted selection of commercial Welsh Lamb across one production season.

Materials and methods
A total of 288 lambs (ewes, castrates and rams, n = 24/gender/time point) were sampled across one season (May, August, November and February, n = 72/time point). At each time point, n = 2 abattoirs were sampled, with samples balanced for sex. One abattoir was used at every time point, with the second abattoir changed at each time point. Chumps were aged for 7-d, before being frozen at −20°C for 14-d minimum. Instrumental colour (CIELAB) was assessed on bloomed chump steaks. Instrumental texture was assessed using Warner Bratzler shear force methodology. Data were statistically analysed using REML.

Results
As the season progressed, lamb chumps were significantly darker (lower L*; $P < 0.05$). There was no significant effect of sex, nor a sex by season interaction on L* values of lamb chumps. Mid-season chumps had higher yellow and higher chroma values (August & November, $P < 0.05$) compared to chumps from May lambs, with February lamb chumps having intermediate colour values. There was a gender by season interaction observed for the redness of lamb chumps, due to a rise in a* values in August for ram chumps, where ram chumps had the highest red values at that time point, relative to the ewes or castrate groups. Chumps from rams were the least red compared to ewes and castrates in November, and ewes always had higher a* values relative to castrates. A significant effect of season, but not sex, was observed on texture, lamb meat at the start of the season had highest shear force relative to meat tested later in the season ($P < 0.05$).

Conclusions
Welsh lamb chumps sampled during the mid-season period was the most tender and most red and highest chroma, relative to meat sampled at other time points.

Acknowledgments
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115

The potential of improved animal welfare as an environmental impact mitigation strategy in dairy sheep farming

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Application
The present work aims to identify the most effective win-win environmental impact mitigation strategies that also enhance animal welfare in dairy sheep farming.

Introduction
The urgent need to limit global warming requires all productive sectors to commit to the reduction of greenhouse gas (GHG) emissions. In this context, the livestock sector, responsible for 14.5% of anthropogenic GHG emissions, is called upon to choose and implement appropriate mitigation solutions. Relatively few studies have quantified the effect of poor animal welfare on the environmental impact of farms. Therefore, it is difficult to hypothesise to which extent good practices of animal welfare improvement might contribute to GHG mitigation. The present work aims to quantify the GHG mitigation potential allowed by the improvement of impaired welfare scenarios in dairy sheep farms from the Mediterranean basin.

Materials and methods
A dairy sheep farm representative of the Mediterranean semi-intensive system was used as a baseline scenario. In this context, seven impaired welfare scenarios, covering the most common impaired welfare conditions in this farming system (according to Sevi et al., 2009; EFSA, 2014), were modelled using data published to date. These scenarios were grouped into the 4 physical welfare domains framework (Mellor, 2017): health domain (mastitis, lameness, gastrointestinal nematodes – GIN), farm environment/behaviour domain (high stocking density, heat stress), and nutrition (water deprivation). Thereafter, Agrecalc©, a carbon calculator developed by Scotland's Rural College, was used to assess the emission intensity (EI) of producing 1 kg of fat and protein-corrected milk for the baseline and welfare scenarios.

Results
An increase in EI was found in all the impaired welfare scenarios when compared with the baseline. The high stocking density scenario, with animals housed in <1.5 m^2/head, was associated with the highest EI, which increased by +10.0% from the baseline. The scenarios within the health domains, i.e., mastitis, GIN and lameness, caused increases in EI of +6.8%, +6.5% and +2.1%, respectively. Lower increases were also shown from the water deprivation (+1.6%) and thermal discomfort (+1.0%) scenarios. Adopting good practices of animal welfare improvement, driving the conditions from impaired to baseline, is likely to proportionally improve farm environmental performance to a similar extent.

Conclusions
Enhancing welfare, besides improving the mental state of the animals, is undoubtedly a prerequisite for resilient and sustainable animal food systems, even before considering any other mitigation options for dairy sheep farming.

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116

Localisation of sheep using Bluetooth Low Energy (BLE) proximity

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Application
Useful information regarding animal behaviour and social contacts can be gathered through monitoring animal location, proximity, and movement. However, many technologies are too expensive or difficult to apply in sheep systems, whereas BLE could present a cheaper and less power intensive option.

Introduction
This study aimed to assess the potential of utilizing BLE as a means of sheep localisation within a field environment. Small beacons (c 14 g) on sheep transmit their identity to static logging and communicating readers either at fixed locations or fitted as collars to other sheep.

Materials and methods
A calibration study using 6 BLE readers and 8 BLE beacons was conducted within a field setting to determine the relationship between a beacon's reported signal strength index (RSSI) and its distance from a BLE reader. Beacons were tested at distances of 1–128 m at log intervals, with a total possible 240 readings per interval. This resulting regression equation, log10 (Beacon Distance from reader) = −2.49 + (RSSI × −0.05) (R2Adjusted = 0.7529, F(1,1375) = 4193, P < .0001), was used to develop a distance prediction equation using RSSI. Two localisation studies are reported showing how a multilateration approach could be used to estimate beacon positions based on combining RSSI from 3 or more readers. This approach was tested firstly in a static beacon study with 6 BLE readers attached to fence posts (2 along the width, and 4 along the length) of a paddock and 16 BLE beacons attached to posts within the paddock in a grid-like array ∼60 × 90 m. This was followed by an on-sheep study where weaned lambs were fitted with both BLE beacons and separate Global Navigation Satellite System (GNSS) devices. In this instance 9 BLE readers were attached to fence posts around 2 adjoining paddocks (∼1.4 Ha); 4 along the length of each outer fence line, and 1 located at the gate between paddocks. Data from 3 stationary lambs is presented to validate the method, comparing location from the GNSS unit with multilateration estimations from the BLE data.

Results
In the static beacon study, 12 of the 16 beacons were located using the multilateration methodology. Estimated beacon locations ranged from 6.53–32.38 m from beacon GNSS locations, with a mean difference of 28.5 m. In the on-sheep study, estimated locations were generated for all 3 lambs. The distances between the estimated location and the lambs GNSS location was 18.38 m, 35.12 m, and 3.91 m for each lamb respectively. Giving a mean difference of 19.14 m between the predicted BLE generated locations and the GNSS locations.

Conclusions
Analysis showed BLE could be utilised for livestock localisation in settings with high densities of BLE readers.

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117

Effects of maternal calcium propionate supplementation on offspring productivity and meat metabolomic profile in sheep

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Application
Nutritional management of dams affects meat metabolomic profile in lambs. From the meat quality perspective, supplementing ewes with calcium propionate seems to be a strategy to improve biosynthesis of fatty acids in lamb's meat and future sensory and chemical studies are suggested.

Introduction
Calcium propionate (CaPr) can play an active role in solving problems related to energy balance during different stages of gestation with direct impact on the offspring growth and development. Therefore, this study determined the effect of dietary CaPr as a source of energy supplementation during the First Half of Gestation (FHG), the Second Half of Gestation (SHG), and during All Gestation (AG), on offspring post-weaning growth performance, meat quality, and meat metabolomic profile.

Materials and methods
Thirty-one pregnant ewes were assigned to one of four treatments: a) supplementation of 30 gd−1 of CaPr during the FHG (day 1 to day 75, $n = 8$); b) supplementation of 30 gd−1 of CaPr during the SHG (day 76 to day 150, $n = 8$); c) supplementation of 30 gd−1 of CaPr during AG (AG, $n = 8$); d) no CaPr supplementation (control; CS, $n = 7$). The ewes were fed a basal diet based on oat hay and corn silage *ad libitum*. Ewes were arranged in a completely randomized with four treatments with an unbalanced design.

Results
Birth weight and weaning weight were lower ($P \leq 0.05$) with FHG, while average daily gain was similar between treatments. Empty body weight was lower ($P \leq 0.05$) with FHG, hot carcass weight was lower ($P \leq 0.05$) in both FHG and AG while hot carcass yield was lowered ($P \leq 0.05$) with CaPr treatments (FHG, SHG and AG). Meat color and texture were similar between treatments. A principal component analysis between gestation stages showed a tendency for separating CS and FHG from SHG and AG, and that was explained by 93.7% of the data variability (PC1 = 87.9% and PC2 = 5.8%). Regarding meat metabolomic profile, 23 compounds were positively correlated between all treatments. Only 2 were negatively correlated (eicosane and naphthalene 1,2,3) with CS; but tetradecanoic acid, hexadecane, undecane 5-methyl, (-)-alpha, hexadecenoic acid, octadecanoic acid, and octadecane had a highly significant correlation ($P \leq 0.05$) with FHG.

Conclusions
Overall, dam supplementation with CaPr during different periods of gestation provokes changes in meat metabolites related to the biosynthesis of fatty acids in lambs without changing lamb's growth performance and carcass quality traits.

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118 (Invited Speaker)

Core vaccination – Optimising sheep health

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Animal Health is regularly overlooked with regards to the contribution it can make to improving sustainability on farm in favour of nutrition and genetics. However, it is reported that 20% of animal production is lost due to disease (OIE, 2015).
Poor animal health can affect environmental sustainability by:

- Increasing resource use for the same level of output
- Increase antibiotic use and adding antimicrobial load to the environment thereby negatively impacting microbial ecosystems
- Requiring more animals to be kept per unit of production and therefore creating more GHGs and associated environmental challenges.

Vaccinations prevent and control infectious diseases, thus reducing the need for antimicrobial treatments. Preventative health protocols can deliver higher health and welfare and optimise productivity in any given sector. There are a wide range of effective livestock vaccines available in the UK, but the current uptake is low, especially in the ruminant sectors. In a post Brexit environment, this offers a significant opportunity to reduce disease and increase productivity and sustainability.
The concept of core vaccines has already been proven and adopted in human health and companion animals in the UK, and to a greater extent across the vertically integrated UK pig and poultry sectors. In contrast, the AHDB 2018 report on vaccination usage indicated that vaccination penetration was on average, circa 30% for endemic diseases in the UK cattle and sheep sectors.
MSD Animal Health has developed a core vaccine protocol for ruminants focusing on preventative endemic diseases. A two-tier system has been developed, with Category 1 focusing on diseases which have a high prevalence and/or high risk to the entire UK population and Category 2 incorporating best practice/farm specific.
The concept of Core Vaccination for the ruminant sector has recently been acknowledged by the UK's National Office for Animal Health (NOAH), the governance body for Animal Health companies in the UK. In May 2022, it published its Livestock Vaccination Guideline

(LVG) for both the cattle and sheep sectors. The LVG for sheep sets out the recommended default set of vaccinations for both adult sheep and lambs. The protocol adopted in this study is entirely consistent with the NOAH Livestock Vaccination Guideline.
This paper will focus on the results of a small group of NSA Next Generation ambassadors who, over the last two sheep breeding cycles have implemented core vaccination across their flocks. Vaccines adopted include those for Enzootic abortion, Toxoplasmosis, Clostridial, Pasturella and Footrot. A suite of KPIs have been monitored during the course of the project seeking to identify improvements in performance and productivity.

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119 (Not Present)

Quantifying the direct impacts of parasitism on lamb methane emissions

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Application
Through quantifying the variable effects of parasitism on livestock greenhouse gas (GHG) emissions over the duration of infection, we can improve the accuracy of livestock emissions calculations. This will enable improvements in animal health to be more accurately considered when collating national GHG inventories.

Introduction
A major source of greenhouse gas emissions from the agricultural sector comes in the form of methane, produced as a by-product when ruminants digest food. A pilot study found that gastrointestinal parasitism can affect the daily methane yield (grams of methane per kilogram of dry matter intake; g CH4/ kg DMI) in lambs. Parasitised lambs had daily methane yields 33% higher than in non-parasitised lambs near the peak of a Teladorsagia circumcincta (gutworm) infection [Fox et al., 2018]. However, due to the dynamic nature of host-parasite relationships, the effects of parasitism can be expected to vary over time. We conducted a longitudinal study aiming to quantify the effects of parasitism on lamb methane emissions over the duration of a T.circumcincta infection and capture any varying effect on daily methane yields.

Materials and methods
Repeat measurements of growing lambs' methane emissions, live-weights and faecal egg counts (FECs) were taken every ~10 days for 58 days of a parasite infection (32 lambs in 8 groups) and compared to repeat measurements from non-parasitised lambs (32 lambs in 8 groups). Feed intakes were measured daily and used to calculate daily methane yield. The parasitised lambs were infected with 7,000 T.-circumcincta larvae 3-times per week. Methane emissions were measured using GreenCow respiration chambers. FECs were performed using the modified floatation technique with a sensitivity of one egg per gram of faeces. Data were analysed using linear mixed-effects models with REML, accounting for the random effects of group ID and respiration chamber where appropriate. All statistical analyses were performed in R (version 3.6.3).

Results
Taking frequent repeat measurements enabled the variations in methane yield at different stages of parasitism to be quantified. The results showed methane yields were higher in parasitised lambs compared to non-parasitised lambs between Day 10 and Day 48 of infection, and these higher methane yields were considered statistically significant between Day 20 and Day 38 of infection ($p < 0.05$).

Conclusions
T. circumcincta parasitism causes an increase in daily methane yield for a prolonged period of time during a trickle infection. Due to the ubiquity of this parasite across temperate zones, these results could improve methane emission calculations on a global scale and inform new methane mitigation strategies.

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120

Stress and Reproduction Interplay: Novel Epigenetic Markers in Response to Shearing Patterns in Australian Merino Sheep (Ovis aries)

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Application
Our genomics and endocrinology research will provide the basis to enable farmers to reliable tool for assessing the reproductive and stress status of their animals so they can make management changes to reduce stress and improve performance and productivity.

Introduction
Merino sheep provide significant contributions to Australia's economy and food supply. Wool production can be impacted by climate and it is important to monitor individual performance using newly available tools. Our research has focussed on validating a practical method of wool hormone and DNA sampling for the evaluation of hormone profiles and epigenetic markers for research purposes, and to understand how hormonal variation may be related to wool phenotype and sheep productivity.

Materials and methods
A suite of field and laboratory methods we used including GPS collars, wool cortisol, and epigenetic change between ewes and lambs identified using Illumina NovaSeq RRBS. Once shorn ewes (n = 24) were kept on their full fleece throughout the entire gestation period, whereas twice (early) shorn ewes (n = 24) had their wool shorn pre-joining. Top-knot wool sample was taken from ewes during pre-joining, day 50 (mid-gestation), and day 90 (late gestation) for laboratory analysis. Ewes were pregnancy scanned at mid-gestation to determine whether they were early or late parturition (this confirmation is provided by the pregnancy scanner based on fetus size). Top-knot wool sample was also taken from the lambs at weaning for hormone and wool quality testing. Ear tissue was taken from ewes at day 50 (mid-gestation) and from lambs at lamb marking for DNA analysis.

Results
Results showed that twice or early shorn ewes grazed 10% higher and maintained stronger body condition than once shorn ewes. Wool cortisol levels were also significantly lower in the early shorn ewes between mid- and late gestation. Lambs bred from twice shorn ewes had on average better visual wool quality parameters in terms of micron, spin finesses, and curvature. For the DNA methylation results, when comparing a group of once sheared with twice sheared ewes, we have discovered one locus (Chr20:50404014) that was significantly differentially methylated [False Discovery Rate (FDR) = 0.005]. This locus is upstream of a protein-coding gene (ENSOARG00000002778.1), which shows similarities to the forkhead box C1 (FOXC1) mRNA using BLAST searches. To further our understanding of the potential interaction between pregnancy status and shearing frequency of the ewes, we performed further differential methylation analysis using a combination of shearing treatment and pregnancy scanning status. The comparisons (1) late pregnancy vs. early pregnancy for ewes with one shearing treatment and (2) late pregnancy vs. early pregnancy for sheep with two shearing treatments were carried out to identify associations between loci and pregnancy duration for sheep with either one or two shearing events. We discovered that 36 gene loci were significantly modulated either between different shearing treatments or late vs. early pregnancy status of ewes.

Conclusions
The results suggest that maternal pregnancy and nutritional status during gestation influence DNA methylation. We further investigated DNA methylation in lambs and identified 16 annotated gene loci that showed epigenetic modulation as a result of being born from an early or late-stage pregnancy. From the genomics data, we pointed out that ewes go through epigenetic modifications during gestation, and there is a degree of intra-individual variation in the reproductive performance of ewes, which could be due to combination of intrinsic (genetic and physiological) and extrinsic (management and climatic) factors. Collectively, this research provides novel dataset combining physiological, molecular epigenetics, and digital tracking indices that advances our understanding of how Merino ewes respond to shearing frequency, and this information could guide further research on Merino sheep breeding and welfare.

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121

Alpha-linolenic and ascorbic acid reverses the seasonal variations of ram semen quality and testosterone concentration

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Application
This study will provide solutions for rams' flushing diet before breeding season to improve semen quality to optimize the conception rate.

Introduction
Indigenous genetic material is crucial in developing adapted breeds, especially following the recent adverse effects of climate change (Ngcobo et al., 2022). Nevertheless, various indigenous sheep breeds are endangered with some already extinct (DAD-IS, 2022). Advanced reproductive technologies are capable to reverse the breed after extinction through frozen-thawed semen and oocytes (Salamon and Maxwell, 2000). Nonetheless, freezing ram semen is still a challenge. Alpha-Linolenic acid is proven to improve semen quality and in-vivo fertility (Singh et al., 2022). The objective of this study was to determine the effects of alpha-linolenic and ascorbic acid on the seasonal variations of semen quality and testosterone concentration.

Materials and methods
The study was conducted at the Agricultural Research Council Animal Production Institute (ARC-API). A total of fifteen South African indigenous rams were used in this study. Five treatment diets (positive and negative control, diets 1, 2, and 3) were formulated. The basal diet was formulated and considered as a positive control, whereas the negative control was the ARC-API standard diet. Diet 1 was the basal diet, topped with 5% flaxseed oil. Diet 2 was the basal diet topped with 4% ascorbic acid, whereas diet 3 was the basal diet topped with both 5% flaxseed oil + 4% ascorbic acid. Semen samples were collected with the aid of an artificial vagina following the training period of 2 weeks. Blood samples were collected with the use of an 18G needle connected to the vacutainer tube. Both semen and blood samples were repeated eight times each season (spring, summer, autumn, and winter), after sixty days following dietary supplementation with the treatment diets to allow the spermatogenesis period. Data were subjected to the General Linear Model (GLM) in Minitab 2017. Treatment means were separated using Fisher's t-test and considered significantly different when P-value is less than 0.05.

Results
Diet and season had an impact on the progressive and total motility, and testosterone concentration. For instance, negative control during the spring season had the lowest progressive motility (42.84 ± 5.32) followed by the summer (49.38 ± 4.49), winter (62.46 ± 4.35), and autumn, (63.26 ± 3.58). Notably, when treatment diets were introduced, improvements were realized, and there were significant differences ($P < 0.05$) among the seasons following supplement diets 1, 2, and 3, except for diet 1 of the autumn season (53.83 ± 4.16). Total motility did not differ significantly ($P > 0.05$) between the seasons when negative and positive control were supplemented nevertheless, there were significant ($P < 0.05$) improvements when diets 1, 2, and 3 were supplemented. Testosterone concentration was significantly influenced by the seasons when negative and positive control diets were supplemented. However, supplementing diet 3 reversed the influence of the season on the testosterone concentration (spring, 27.52 ± 4.42; summer, 20.23 ± 5.11; autumn, 25.24 ± 3.96; and winter, 25.92 ± 4.42).

Conclusions
In conclusion, seasons do affect semen quality and testosterone concentration. However, alpha-linolenic and ascorbic acid can reverse the seasonal variations in both semen quality and testosterone concentration.

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122

Cis-eQTL discovery of immune related molecular phenotypes in sheep

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Application
Detect novel genomic markers influencing gene expression, an intermediate phenotype which could inform future breeding strategies.

Introduction
Expression Quantitative Loci (eQTLs) are genomic markers that explain a proportion of variance in a gene expression molecular phenotype. Analysing eQTLs can allow us to identify candidate genes of interest for novel traits (Majewski and Pastinen, 2011). eQTLs for complex traits have been well-documented in humans but only a few have been published in sheep (Yuan et al., 2021). This paper presents early work on investigating immune eQTLs in sheep in order to identify immune-related genetic markers that could be useful for breeding.

Materials and methods
Healthy lambs from two populations (1 – Scottish Blackface, 2 – Texel X Scotch Mule) were chosen for the study (n = 102). Blood samples were collected into Tempus™ or EDTA tubes for RNA or DNA isolation, respectively. RNA samples were sequenced on an Illumina Novaseq platform, and genotyping was performed using the Ovine 50K SNP chip.
From the RNA-sequencing data gene expression profiles were measured using the pseudo-alignment package Kallisto. Data were normalised using the Variance Stabilising Transformation (arcsine-transformation) in DESeq2 and Principal Component Analysis was performed to reveal underlying sample structure in the RNA-sequencing dataset.
An eQTL analysis was performed using the MatrixQTL package in R. A linear regression model was used to test for association between Single Nucleotide Polymorphisms (SNPs) and transcripts. The first Principal Component was included as a covariate to account for population structure, and a Bonferonni correction was applied to account for multiple association testing. Significant SNPs were defined as cis-eQTL if they fell within a 1Mb window up or downstream of a transcription start site.

Results
Principal Component Analysis showed that 51.5% of variation was explained by the first 6 components. The two populations segregated along the 1st principal component, necessitating its inclusion as a covariate in the linear regression model. In addition, network cluster analysis of gene expression profiles indicated large clusters of immune-related genes expressed in blood and little population-specific gene expression. Data analysis is currently ongoing and full results will be presented at the conference.

Conclusions
This represents one of the first uses of eQTL analysis in sheep and to our knowledge the first to investigate a tissue type relevant to immune gene expression. As the next stage of this project, we plan to generate a reference panel of immune cell type specific transcriptomes, to deconvolute the expression profiles from whole blood. Future work will seek to integrate these results with publically available datasets from Genome Wide Association Studies, to enable the discovery of genomic regions driving immune-related phenotypes.

Acknowledgments
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123

Championing better sheep scab control through partnership across the sheep sector

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Application
The principles and pathway followed by the Northern Ireland Sheep Scab Group (NISSG) provide a template for others to develop a participatory action project involving farmers and other industry professionals to identify barriers and opportunities to improve endemic disease control.

Introduction
Farmer, rather than state, led endemic disease control has become common-place in the United Kingdom (UK). Sheep scab is endemic in all parts of the British Isles, with a substantial welfare, economic and environmental cost. Yet scab is often considered a taboo within the farming community. Statutory control of scab was abandoned in 1992. Since then, scab outbreaks have increased. Within Northern Ireland (NI) no research or control activity had been undertaken prior to 2019 despite scab being a Notifiable disease. In 2019, informal discussions within the sheep industry led to the formation of the NISSG – a voluntary coalition of stakeholders, focusing on improved scab control in NI.

Materials and methods
The NISSG developed organically, driven by the motivation of the farmers at its core as a participatory action group. Through discussion groups they identified opportunities to improve scab control as well as competencies required within the industry to deliver the necessary action. They also identified barriers to progress and the necessity to engage specialists and researchers to develop a scab control plan.

Results
The barriers identified included knowledge gaps in scab mite biology, effective treatment and prevention strategies. Poor practice, including use of unauthorised treatments, and limited data on the distribution of scab in NI were also identified. The NISSG developed a partnership with veterinary scientists and animal and social researchers, which successfully secured funding from the BBSRC. These funds are currently facilitating knowledge exchange activities and providing support for on-farm diagnostic investigations into suspected scab outbreaks. Three hundred and fifty farmers, veterinary surgeons and SQP (Suitably Qualified Persons) prescribers attended open meetings in 2022 to update their knowledge of scab control. Additionally, these events enabled the project team to further explore potential control measures and identified further barriers, including farmers' fear of state controls. Veterinary surgeons were engaged in discussions promoting best-practice in prevention, diagnosis and treating. Subsequently a self-reporting scheme, led by leading industry researchers to improve scab control in NI was launched. Through this, 100 farmers will receive on-farm diagnostic and treatment support. A comprehensive questionnaire was produced to better quantify the barriers and impacts of scab infestation.

Conclusions
Harnessing and resourcing farmers at their own self-identified point of need has resulted in more openness in discussing scab, greater awareness of best practice disease control and the generation of data towards the development of a national control programme after decades of scab control inactivity.

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124

Dietary effects of copper sulphate on nutrients utilization, weight gain and rumen fermentation characteristics of goats

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Application
The use of dietary copper sulphate in goats' diet will aid nutrients utilization, production in an eco-friendly environment, hence reduce environmental pollution.

Introduction
Copper (Cu), a micro-mineral, is essential for the growth and optimum health of livestock. Several studies have reported the effects of copper sulphate (CuSO4) to aid Cu bioavailability, stabilize the rumen pH, renders the rumen environment more stable and decrease faecal Cu excretion in pigs. Hence, this study evaluated the supplemental effects of graded levels of dietary CuSO4 on growth performance and rumen fermentation characteristics in goats.

Materials and methods
A concentrate diet was formulated to meet the nutrients requirement by growing goats (NRC, 2007), divided into five equal portions; and copper sulphate (CuSO4) was thoroughly mixed with the diets at 0 (control), 5, 10, 15 and 20 mg/kg of CuSO4 as feed additives. A total of 25 male, growing West African Dwarf (WAD) goats (6.10 ± 1.00 kg) were randomly assigned to the diets (five goats per treatment) in a Completely Randomized Design experiment for 63 days to evaluate its effects on nutrients utilization, weight change, rumen microbial counts, isolates and volatile fatty acids of the growing goats. Feed, faecal and urine samples were analysed for nutrients composition using AOAC (2002) methods. All data generated were subjected to statistical analysis using one-way analysis of variance (ANOVA) with SPSS version 23.

Results
Nutrients (proximate and fibre fractions) intake and apparent digestibility coefficients of crude fibre and fibre fractions were significantly ($P < 0.05$) influenced. Acetic, proprionic, butyric, valeric, lactic acids and total volatile fatty acid concentrations were significantly ($P < 0.05$) higher (7.41 ± 0.21, 7.10 ± 0.21, 6.82 ± 0.22, 6.78 ± 0.22, 9.24 ± 0.27 and 99.96 ± 0.36, respectively) in goats fed the diet with 5 mg/kg of CuSO4 compared to the other dietary treatments, an indication that fermentation of fibre is favoured at this level. pH and NH3 production in goats supplemented 20 mg/kg of CUSO4 was the highest value recorded. Total microbial (bacteria, fungi and coliforms) counts were affected by the treatment. Fibrolytic organisms were most identified/isolated in all the treatments. Even though there was no significant effect ($P > 0.05$) in the initial weights, but the final weight, weight gain and feed conversion ratio of goats fed 5 mg/kg supplementation of CuSO4 showed significant improvement.

Conclusions
Supplementation with the lowest dose of CuSO4 (5 mg/kg) in the growing goat diet could be beneficial for optimum rumen function, growth performance and may reduce environmental pollution.

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125

Growth performance and prevalence of gastrointestinal nematodes in Xhosa goats raised in grassland and forestland vegetation types

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Application
Most tree legume forages in the tropics possess anthelmintic functions that reduce the need for using commercial drugs. That should be considered in developing goat health programmes.

Introduction
Gastrointestinal nematodes (GIN) cause great losses in productivity of goats (Zvinorova et al., 2016; Dey et al., 2020). The objective of the study was to determine the effect of GIN on growth performance in Xhosa goats that are indigenous to Southern Africa, raised in grassland and forestland vegetation types.

Materials and methods
Body condition scores (BCS), body weights (BW), and faecal egg counts (FEC) were assessed in 7-month-old goats raised in grassland (n = 165) and forestland (n = 144) vegetation types, respectively. All measurements were taken once in each of the hot-dry, hot-wet, post-rainy and cool-dry seasons. Faecal samples collected from the rectum were analysed using the modified McMaster technique and the samples were cultured to enable identification of the nematodes. The BCS, BW and FEC were analysed using repeated measures analyses.

Results
Goats with good BCS and BW had lower FEC on both vegetation types. As expected, there was a higher ($P < 0.05$) prevalence of GIN eggs during the hot-wet season. Goats in the forestland had higher ($P < 0.05$) BCS and lower FEC compared to those in grassland. Strongyloides and Nematodirus eggs declined in the post-rainy season in both vegetation types. The month of sampling significantly influenced FEC in the indigenous goats. The reduction in BCS and BW was higher ($P < 0.05$) in the grassland than in the forestlands. During the hot-dry season, goats in the grassland vegetation showed significant losses in BCS and BW, unlike those in the forestlands.

Conclusions
Goats kept under grasslands had higher incidence of GIN infestations than those raised in forestlands. The higher performance of goats kept in the forestlands could be explained by the improved nutrition and content of secondary compounds with anthelmintic effects.

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126

Integrating multi-species swards into parasite management in sheep under climate change

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Application
The work seeks to evaluate and optimise the use of mixed swards to manage parasite infections in grazing sheep under current and future conditions.

Introduction
Gastrointestinal nematodes (GIN) are a common and important cause of disease in grazing ruminants. Resistance to anthelmintics is a widespread issue in GIN and a major dilemma faced by the livestock industry is the requirement to maintain effective parasite control while reducing chemical anthelmintic use, to ensure continued efficacy and minimise negative environmental consequences. The negative impacts of parasites and the need for anthelmintic treatment can be reduced by grazing multi-species swards (MSS), which can reduce parasite burdens while enhancing nutrition. Although impacts of individual plant species on parasites, and effects of MSS on animal performance, have been assessed (e.g. Marley et al., 2003, 2006; Athanasiadou and Kyriazakis, 2004), there is a lack of information on the epidemiological consequences of MSS grazing and how to design MSS grazing platforms to maximise parasite management benefits.

Materials and methods
Parasite infections were compared over one year in two groups of lambs ($n = 39,39$) rotationally grazing each of perennial ryegrass with white clover (PRG), or additionally enriched with red clover, ribwort plantain and chicory (MSS). Nematode faecal egg counts (FEC) monthly, pasture larval counts (PLC) (Molento et al., 2016) at three time points, and end-of-season abomasal worm counts were measured. To evaluate the epidemiological consequences of reductions in parasite burdens through decreased onward infection pressure, FEC data were entered into a mechanistic predictive model of nematode population dynamics (Rose et al., 2015), extended to account for sheep movement between fields (McFarland et al., 2022). The same model was used to simulate different rotation intervals under current and projected future climates across the UK, in order to maximise impacts of reduced FEC and to evaluate the feasibility of optimising both epidemiological benefits and grass / MSS utilisation.

Results
No significant differences were observed between PRG and MSS groups in FEC, PLC or abomasal worm counts ($p > 0.05$). Live weight gain, however, was significantly greater in MSS than PRG groups ($p < 0.05$), leading to a c.10% weight advantage at the end of the grazing season. Because FEC was not reduced in the MSS group, modelling did not predict reduced infection pressure on MSS fields. Simulations showed that rotational grazing did not have significant benefits for GIN infection pressure over set-stocking the same area of land, unless re-grazing intervals were extended beyond realistic limits. Climate change scenarios tended towards more rapid development of infective larvae at pasture, and more rapid decline in infectivity, affording opportunities for greater control through rotational grazing provided residence periods were kept below one week.

Conclusions
Although MSS afforded benefits for grazing lamb performance under natural GIN infection, these could not be attributed to antiparasitic activity and might be primarily nutritional. Implementing modelling alongside data collection can help predict seasonal risk of transmission of GINs, and these models can be extended to optimise the implementation of this novel combination of control strategies.

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127

Influence of age and diet on carcass characteristics and meat quality in Rambouillet ewes

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Application
This study can help famer's decisions when selling ewes according to age and feeding regime.

Introduction
Adults or cull ewes may represent an economical option in sheep production systems if the selling price could be based on the carcass weight and number of edible tissues. Therefore, it is relevant to know carcass characteristics of cull ewes and for farmers this could result in a viable option for the sale of this type of animals. Thus, this study determined the effect of age and diet on carcass characteristics and meat quality parameters of Rambouillet ewes.

Materials and methods
Forty ewes with different ages (n = 20 yearling ewes and n = 20 cull ewes) were fed with alfalfa hay (AH) or 100% concentrate diet (CD). Treatments were as follows: a) ten cull ewes were fed only with AH, b) ten yearling ewes were fed only with AH, c) ten cull ewes were feed with CD, d) ten yearling ewes were fed CD. Productive performance, carcass characteristics, and meat quality were recorded. Animals had 10 days of adaptation and 35 days for data collection.

Results
Dry matter intake was grater ($P < 0.05$) for CD. Feed conversion had no differences. The pH at 45 min and 24 h, carcass length, leg length, leg width, thorax width, and thorax perimeter were similar between treatments. Hot carcass weight was heavier ($P < 0.05$) in cull ewes, cold carcass weight was increased ($P < 0.05$) by CD. Carcass yield (CY) was heavier in CD ($P < 0.05$). Cull ewes had greater ($P < 0.05$) meat color values (L*, a*, b*, c*, and h*) compared with yearling ewes. The color changes increased by age at five days ($P < 0.05$), but a decrease ($P < 0.05$) by diet was observed at ten days. Cathepsins B, B+L, and Lowry protein content were similar among treatments. No significant interactions were found.

Conclusions
Our results suggested that feeding cull ewes with concentrate diets could improve body weight gain and carcass yield with respect to feeding only with alfalfa hay.

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128 (Invited Speaker)

Feed additives in the current climate

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Milk price in the UK has increased significantly and now averages over 45 p/l in October.
We may believe that this puts producers in an advantageous position moving into winter 2022/23, especially as the UK has so far maintained both quantity and quality of milk production.
With weather related reductions in forage quantity and quality some producers will need to sustain milk production using bought in feeds. However, feed prices have increased by over 30% recently and therefore the higher milk price is not necessarily creating improved returns for farmers.
There is therefore pressure to extract the maximum value from home grown forage not only from an economic but also from a carbon footprint basis. With the carbon footprint of silage being less than 100 kg CO2 equivalent/tonne compared to grains and grain by products at 500–1000 kg CO2 equivalent/tonne and fat sources at >2000 kg CO2 equivalent/tonne, as we strive to reduce our carbon expenditure in dairying getting the most from lower carbon products like home grown forage is the way to go.
How can we help this be achieved:

1. Ruminal health – buffer and condition
2. Feed utilisation

The focus on creating optimal ruminal environment for the promotion of increased feed utilisation by preferential ruminal bacterial colonies. The addition of ruminal buffers such as Acid Buf, a calcareous marine algae, help in the maintenance in ruminal pH above the subacute ruminal acidosis (SARA) risks area >pH 5.8. Using a long-lasting buffer allows the neutralisation of excess acid in the rumen via feed intake or produced in the rumen from starchy feed breakdown, reducing the negative impact on fibrolytic bacteria and damage to the rumen wall.
The maintenance of a higher pH is preferential for bacteria which break down fibre. There is more that can be done to promote these bacterial colonies such as using a prebiotic such as live yeast. The delivery of live colony forming units (CFUs) is key in gaining results. Data has shown the increase in volatile fatty acid (VFA) production with the increase in CFU supplied from live yeast. Live yeasts such as Vistacell condition the ruminal environment by:

- competing against lactate producing bacteria, reducing the risk of falls in ruminal pH
- maintaining an anaerobic environment through its own respiration
- its probiotic effect as a nutrient source to ruminal bacterial colonies

The maintenance of a healthy ruminal environment promotes preferential rumen bacteria and therefore leads to increases in feed digestibility and efficiency.
NDF is made up of 3 components: hemicellulose, cellulose, and lignin, each less digestible than the one before. Lignin is highly undigestible and therefore remains in the rumen for a long time, this increased lag time can have effects on feed intakes. Diets that contain NDF in excess of 50% are considered to impede dry matter intake (DMI) and ADF levels above 28% in the ration to impair digestion of the ration. Ensuring that chop length of forage is short and avoid overly long fibres, adding water to rations, extended mixing times to avoid sorting are common ways of aiding high fibre intakes, but do not work on NDF specifically.
Using a feed pre-treatment such as Vista Pre-T can be a further step to support increased NDF digestibility. Vista Pre-T works to make the cellulose and hemicellulose fibre fractions more accessible to the fibre-digesting microorganisms in the rumen. By reducing the digestion lag time Vista Pre-T can boost the rumen's natural ability to digest forage and allows nutritionists and producers to use forage smarter.
Creating excellent ruminal health supported by buffers and live yeasts partnered with feed pre-treatments can increase the nutritive value that can be extracted from home grown forage to increase herd productivity.

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129 (Invited Speaker)

The rumen Microbiome. Impact of diet composition on bacterial community

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Rumen is an anaerobic chamber, and it is inhabited by a dense and different strict anaerobes microbial population: Bacteria, Archaea, Fungi and Protozoa. They are involved in the fermentation and degradation of plants material which result in the conversion into digestible compounds as volatile fatty acids (VFAs) and such a source of energy. The archaeal and bacterial domains are essential for rumen activities. Many taxa are not abundant in the rumen, but they are also important for fermentation and digestion. The rumen microbiome is influenced by several factors including host genetics and species, animal behaviour, and diet's characteristics or composition. There are different dietary interventions which could influence microbiota: improving the quality of ingredients, changing the F:C ratio of the diet, and using feed additives. In general, any activity on the diet could influence the whole rumen microbiome, and not only a specific population. In the present study, we investigated the potential of molasses in modulating the rumen microbiota composition and in vitro volatile fatty acid (VFAs) production. For the trials, six different based liquid feed, equally representative of beet and cane molasses, were randomly selected from a variety of samples, and incubated with rumen fluid for 24 hours in vitro. Three replicates of each molasses, and three replicated of control (CTR, with no molasses addition) were used for each of two different runs. VFAs analysis was carried out by sampling incubation flasks at 1,2,3,4,6,8,24 h. For microbiota analysis, samples were collected after 12 and 24 h of incubation, and then subjected to DNA extraction. Purified DNA was then analysed via V3-V4 16S rRNA gene sequencing on an Illumina MiSeq platform. Obtained results showed how VFAs composition was affected by molasses inclusion: acetic acid resulted higher in the CTR group (73.5 mmol), while propionic acid acted differently, being higher in beet and cane molasses (19.6 mmol; 18.6 mmol, respectively). Interestingly, butyric acid increased especially in the cane group (23.2 mmol). Moreover, total VFA production was higher in beet and cane than in CTR at 24 h (53.3 mmol; 54.3 mmol; 45.1 mmol, respectively). Molasses addition deeply influenced the composition of the rumen microbiota. In particular, the relative abundance of Veillonellaceae (6.48% and 8.67% in molasses compared to 4.54% in CTR), Streptococcaceae (19.62% and 28.10% in molasses compared to 6.23% in CTR), and Fibrobacteraceae (0.90% and 0.88% in molasses compared to 0.62% in CTR) increased in beet and cane compared to the CTR group, while Prevotellaceae, the most predominant family in the rumen, decreased compared to CTR (37.13%, 28.88%, 49.6% respectively). Another important finding is the lower proportion of Methanobacteriaceae following the addition of molasses compared to CTR (0.26%; 0.28%; 0.43%, respectively). In conclusion, this study showed how much the diet composition, and in particular molasses addition, would impact the rumen microbial composition, a change which reflects also on VFA production and composition.

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130 (Invited Speaker)

Amino acid balancing: Precision nutrition for performance, sustainability and profitability

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An average UK dairy diet is 17.5% crude protein with a nitrogen use efficiency (NUE) of below 25%.
This compares with best practices in other countries where with the application of Amino Acid balancing ration crude proteins is ~16% and NUE is above 30%. Less than 3 kg of protein is required to produce 1 kg milk protein as compared to a typical UK situation were 4 kg of protein is required. There is a huge potential to increase nitrogen capture in milk protein, reduce nitrogen waste in urine, reduce imported protein and, hence, the carbon footprint as well as increase farmer profitability.
Amino acids are the building blocks of protein. Of the 20 amino acids, 10 are essential which have to be supplied in the diet. Rumen by-pass methionine and lysine, essential Amino acids, are now readily available for use as ingredients in formulating dairy rations.
Why do cows need protein? Protein is a source of amino acids. Today 95% of UK dairy diets are limited in their supply of metabolizable methionine for optimizing milk protein and milk fat yield. This will be further aggravated as feeding lower crude protein diets is encouraged to meet sustainability targets. As pressure grows to reduce soybean meal (rich in lysine) feeding, then lysine will also become increasingly colimiting in rations. Lysine is needed to meet requirements for milk and milk component yield.
Meeting the requirement for amino acids becomes increasingly difficult with lower crude protein diets and higher milk yields. Therefore, the necessity of adding rumen by-pass lysine and methionine into the formulation matrix should no longer be questioned. The use of single amino acids in ration formulation has been adopted for many decades in poultry and pig diets.
The major ration formulation system in the UK (Feed into Milk) does contain amino acid formulation capabilities and a milk quality decision support system but is 20 years old and based on older trial work. INRA 2007 and 2019 and CNCPS version 6.5 & 7.0 offer updated amino acid supply and requirement calculations. Meta-analysis approaches have improved the ability to predict responses. Yet, there is

still relatively low usage with under 10% of UK dairy cows being rationed for amino acids, although five years ago it was actually less than 1%.
Significant improvements in dairy health, fertility, milk quality and performance can be achieved by balancing for amino acids. In trials, the responses can be up to 2.8 kg of energy corrected milk, with an average increase of +0.13% in milk protein and +0.16% in milk fat. Reductions in embryo loss (13%) and a reduction of 24 days to conception and 7% reduction in culling rate have been noted.
Amino acid balancing and the use of rumen by-pass amino acid products as part of a precision nutrition approach are a significant opportunity to reduce dietary protein and increase milk protein capture and, hence, improve NUE and performance. In addition, fertility and longevity can be improved. These benefits combine to reduce the carbon footprint of the UK dairy industry.

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131 (Invited Speaker)

Feeding the Rumen for Reduced Methane Emissions

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In studying energy metabolism, nutritionists have measured the impact of diet composition on methane emissions of ruminants for over 150 years. However, concerns over the impact of methane emissions from the ruminant livestock sector on climate change have resulted in a massive increase in research over the last 30 years that has focused on finding feeding and management strategies for reducing methane emissions from cattle and sheep. More recent government and industry commitments for achieving methane inventory reductions and net-zero carbon emissions have further heightened interest in dietary strategies and feed additives that can reduce total methane production attributed to ruminant meat and milk production. The resulting increase in the availability of experimental results has led to the publication of several recent meta-analyses of published and unpublished data investigating key dietary factors that determine methane emission, methane yield (methane per unit feed dry matter intake [DMI]), and methane 'intensity' (methane per unit of product). In one of the first meta-analyses of methane emission data, Bratzler and Forbes (1940) reported that digestible carbohydrate intake was the primary determinant of methane emission by cattle. Numerous subsequent meta-analyses of methane emission measurements have demonstrated that feed DMI is the primary determinant of methane production, whilst methane yield is affected by the proportions of forage and concentrates consumed. The type and degradability of the carbohydrate fed have a major effect on methane yield, with increases in starch and decreases in fibre concentrations, and increases in fibre digestibility associated with reduced methane yield.
Whilst also a diet component and not considered a feed additive per se, feeding supplemental lipids, particularly polyunsaturated fats, has long been known to reduce methane yield. A myriad of other feed supplements and additives are currently being investigated as potential mitigators of methane emissions from ruminants. In many cases compounds found to be effective in vitro are not effective in vivo, and compounds effective in sheep may not be effective in lactating dairy cows. A number of feed additives are already approved for use in some countries, including nitrate and the methyl coenzyme M reductase inhibitor 3-nitrooxypropanol. In addition, there is considerable interest in seaweed as a methane inhibiting feed supplement. The most effective seaweeds are those that contain bromoform, one of many methane inhibiting halomethane compounds, but these seaweed species typically contain high levels of iodine, which may limit their permissible inclusion rate in feed for food producing animals. There are also several plant-based products purported to be effective at reducing methane emission through various mechanisms, but in many cases their efficacy in vivo is equivocal. Although a number of dietary supplements are effective as mitigators of methane emission by ruminants, the cost of the products relative to the economic value of reduced methane emission is currently a limit to their widespread use (e.g., lipid supplements). In this regard, the adoption of 'best practice' in diet formulation and management remains an effective and viable option for reducing methane emissions by ruminants.

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132

The effect of sward type on average daily gain, meat fatty acid and vitamin E profile of co-grazed heifers and lambs

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Application
Grazing multispecies swards can increase the production performance of beef and lamb and the alpha-linolenic acid (ALA) levels in the meat.

Introduction
The objective of this study was to determine the effect of four sward types: *Lolium perenne* (PRG) (receiving 170 kg N/ha/y); permanent pasture (PP) (receiving 135 kg N/ha/y); 6 species (6SP) with *Lolium perenne*, *Phleum pratense*, *Trifolium pratense*, *Trifolium repens*, *Cichorium intybus* and *Plantago lanceolata* (receiving 70 kg N/ha/y); and 12 species (12SP) with *Dactylis glomerata*, *Lotus corniculatus*, *Onobrychis vicifolia*, *Achillea millefolium*, *Petroselinum sativum*, *Sanguisorba minor* in addition to the 6SP mix listed above (receiving 70 kg N/ha/y), on the average daily gain of co-grazed heifers and lambs and the fatty acid and vitamin E profile of the meat produced.

Materials and methods
Swards were rotationally grazed from April to November 2020 by dairy X beef heifers (n = 20 per treatment, turned out at 403 ± 1.48 days of age, mean ± SEM) and ewes (n = 22 per treatment) plus lambs. Heifers were weighed monthly and drafted for slaughter when their estimated fat class on the EUROP grid scale reached 3-. Lambs were weighed fortnightly and drafted for slaughter to achieve a target carcass weight of 21 kg. Post-slaughter, 1 kg of the *longissimus thoracis et lumborum* was collected for subsequent fatty acid and vitamin E analysis.

Results
Average daily gain was greater for heifers grazing the 6SP sward and for lambs grazing both multispecies swards compared to the PRG and PP swards ($P < 0.001$). Total fatty acids (TFA) concentration did not differ significantly in beef and lamb between sward types. The proportion of monounsaturated fatty acids (MUFA) was higher in beef from heifers grazing the PRG (45.8% of TFA) compared to the 12SP (42.3%). While there were no significant differences in the proportion of polyunsaturated fatty acids (PUFA) between treatments, ALA (C18:3n3) was higher in beef from the 12SP (1.6%) than the PRG (1%) and PP (1.1%, $P < 0.001$). MUFA was higher in lamb from the PRG (38.3%) and PP (38.8%) compared to the 6SP (35.2%, $P < 0.01$). PUFA tended to be higher in lamb from multispecies swards with higher ALA from the 6SP (3.1%) and 12SP (3.1%) than the PRG (2.4%) and PP (2.3%, $P < 0.01$). The proportion of saturated fatty acids and concentration of vitamin E in beef and lamb did not differ between sward types.

Conclusions
Overall, grazing multispecies swards increased heifer and lamb average daily gain thereby enhancing animal performance, as well as increasing the proportion of ALA and decreasing the proportion of MUFA.

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133

In-abattoir 3D image parameters of beef carcasses to predict EUROP classification grades and carcass weight

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Application
Using 3-dimensional imaging technology for the prediction of classification grades of beef carcasses, providing an objective method, increasing accuracy in grades awarded.

Introduction
Imaging technology can extract measurements from beef carcasses, allowing for objective grading. Many abattoirs, however, still rely on manual grading due to the required infrastructure and cost, making technology unsuitable for implementation. This study explores the use of 3-dimension imaging technology, requiring limited infrastructure, to predict carcass weight, conformation grade and fat class, resulting in a less invasive, objective classification system.

Materials and methods
Basler Time-of-Flight near-infrared cameras (Basler inc., Exton, PA) captured 3-dimensional images of beef carcasses, on-line in one commercial abattoir in Scotland, over 11-months. Thirty-five frames were captured per carcass. Frames were processed using Halcon software (MVTech Software GmbH, Munchen, Germany). Poor images resulting from rotated or incorrectly cut carcasses, were identified, and

removed (~70%). A total of 70 parameters were extracted from each remaining frame. Thresholds were applied to the dataset to remove outliers (>3 standard deviations from the mean), resulting in 91,678 datapoints of 11,326 carcasses. The coefficients of variance (CV) for each parameter on a per-animal basis were relatively low and consistent (mostly <0.1, ranging from 0-1.6), with rump volumes tending to have greater variance (CV ~0.24 on average). Therefore, datapoints across frames were averaged per carcass resulting in one data row per animal. Simple and Multiple Linear regression models were created for the prediction of EUROP conformation grade and fat class on the 15-point scale, and carcass weight (kg). Using RStudio's lm() function, three sets on 73 individual models were created using each independent variable to predict one of the dependent variables, indicating which were significant ($P < 0.025$). Stepwise models were then created using the stepAIC() function. Either the full set of independent variables or those highlighted as significant in the individual models, were tested.

Results
The linear modes predicted fat, conformation, and carcass weight with low, medium, and high accuracy respectively. Across all models for each dependant variable, the stepwise model using all predictor variables, direction "both", had the highest adjusted R2 values, of 0.244, 0.483, and 0.635 for fat, conformation, and carcass weight respectively, with a maximum of 50 predictor variables being used in the models. The models created using only the variables highlighted as significant in the individual models had the lowest R2 values of 0.238, 0.467, and 0.631 for fat, conformation, and carcass weight respectively.

Conclusions
Three-dimensional imaging technology can predict fat class, conformation grade and carcass weight of beef carcasses with low, medium, and high accuracy respectively. Further prediction methods, such as machine learning techniques will be explored to compare predictive power.

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134

Effect of inclusion of yerba-mate extract in beef cattle diets on nutrient digestibility

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Application
Yerba-mate extract, due to its high levels of secondary compounds, may affect the digestibility of nutrients in ruminant diets.

Introduction
Plant extracts have been used in ruminant diets as an alternative to the use of ionophore antibiotics. However, the secondary bioactive compounds of these extracts can interfere with the efficiency of the digestive processes of the nutrients in the diets of the animals. Yerba mate is a common plant in the southern region of South America and is characterized by having high levels of secondary compounds, as polyphenols, xanthines, in addition to alkaloids and flavonoids. The objective of this study was to evaluate the effect of inclusion of yerba-mate extract (YME) in diets of Nellore cattle on nutrient digestibility.

Materials and methods
Eight rumen-cannulated Nellore steers (initial BW = 402 ± 32 kg) were housed in individual pens with free access to water and feed. Four diets were formulated for the maintenance, with forage:concentrate ratio of 70:30 and 104 g of crude protein (CP) and 659 g of total digestible nutrients (TDN) per kg of dry matter (DM), differing in four levels of YME (0, 5, 10 and 20 g per kg of DM). The experimental design was a replicated contemporary Latin Square, with the four levels of YME considered as treatments. The experimental unit was the animal within each Latin square, comprising 32 experimental units. Each period comprised 21 days (16 days of adaptation and 5 days of collections). To determine total apparent digestibility of DM and nutrients, feed refusals were collected daily. Faeces were sampled twice a day, directly from animal's rectum, for 5 days and the collections started at different time each day (3h delay from one day to the next). Digestibility coefficients were estimated using indigestible neutral-detergent fibre (iNDF). Statistical analysis were carried out testing the normality of the residues (Shapiro-Wilk) and variables were analyzed using mixed models considering the fixed effects of treatments, square and period within the squares and the random effects of animal within the squares. P-values for linear and quadratic effects were determined.

Results
DM intake was not affected by YME inclusion levels ranging from 16.2 to 16.9 (SEM = 0.47) g DM/kg BW/day. In addition, no linear or quadratic effects were observed for nutrient digestibility. The coefficients of digestibility ranged from 0.657 to 0.668 (SEM = 0.008) for DM; from 0.641 to 0.669 (SEM = 0.009) for CP; from 0.763 to 0.804 (SEM = 0.012) form EE; from 0.410 to 0.435 (SEM = 0.011) for NDF; and from 0.407 to 0.428 (SEM = 0.011) for ADF.

Conclusions
Although it contains high levels of secondary compounds, the yerba-mate extract did not affect the digestibility of beef cattle diets, when included in up to 20 g per kg of DM.

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135

Precision feeding emphasises dietary protein over-supply in diets for growing and finishing beef cattle

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Application
A large proportion of the beef sector still formulates diets based on crude protein, and a move to the metabolisable protein system coupled with more accurate prediction of animal intake, has the potential to reduce reliance on supplementary protein sources, thus reducing costs and improving nutrient use efficiency.

Introduction
Precision feeding aims to account for variations in the nutrient requirements of farm animals, thereby increasing the efficiency of nutrient utilisation and optimising animal performance (González et al., 2018). There is subsequently a need to determine if precision livestock feeding techniques can be used to improve the efficiency of feed utilisation within growing and finishing beef cattle production systems.

Materials and methods
Historical, performance data was collected at Harper Adams University from Aberdeen-Angus x Holstein cattle (n = 30) fed a grass silage-based growing diet, and British Blue x Holstein steers (n = 30) fed either concentrate- or forage (Whole crop wheat)-based finishing diets respectively. Data from these studies was subsequently modelled to evaluate the implications of adopting precision feeding in beef cattle production systems under two scenarios. Under **Scenario A** (Commercial practice), the original study diets were formulated to industry specifications (AHDB, 2019), including crude protein concentrations of 140g/kg of dry matter. Whereas, under **Scenario B** (Matched feeding), these original study diets were reformulated to optimise nutrient supply according to recorded animal performance at a group level observed during the experiments. The recorded physical performance data that was introduced into the model under the latter scenario included: dry matter intake, liveweight, and average daily gain, whilst metabolisable protein was used in place of crude protein to determine cattle protein requirements. Nutritional models were constructed according to AFRC (1993) in Microsoft Excel, and results were presented in relation to nutrient supply and diet costs under both scenarios.

Results
The results indicate considerable protein excess, under scenario A, the mean metabolisable protein over-supply was 143%, with a range of 133-157% across the various diets. Under scenario B, diet reformulation based on observed performance data, resulted in the substitution of supplementary protein sources with barley. This reduced diet costs by £0.29/kg gain. However, mean metabolisable protein over-supply was still 117%, with a range of 107-129% across the various diets respectively.

Conclusions
Dietary protein is generally supplied in excess of AFRC (1993) requirements in commercial diets for growing and finishing cattle. Diet formulation based on metabolisable protein rather than crude protein, and the adoption of a precision feeding strategy based on observed animal performance emphasises the potential to reduce diet and environmental costs, whilst maintaining animal performance within beef production systems.

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136

Is Net Zero achievable on beef and sheep farms?

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Application
Achieving Net Zero will require large and coordinated reduction in emissions and changes in land use on beef and sheep farms. Potential emission reductions and the degree of carbon removals needed to offset residual emissions to achieve Net Zero at a farm-level are demonstrated.

Introduction
The Climate Change Committee has recommended a 64% reduction in greenhouse gas emissions from the agriculture and land-use sector to meet the 2050 Net Zero target in the UK. However, it is still unclear how this reduction can be achieved at a farm level. The aims of this study were to explore the opportunities available to reduce GHG emissions and enhance sequestration on Welsh beef and sheep farms. Using real farm data and novel modelling approaches, we investigated the management interventions and land use changes that would be required to deliver Net Zero.

Materials and methods
Baseline carbon footprints were calculated for twenty Welsh beef and sheep farms using AgRE Calc for emission estimates and sequestration estimates from Bangor University's Carbon Footprinting Tool. Scenarios were created to determine the emission reductions possible when a range of mitigation measures were implemented on each farm and the area of woodland needed to offset the residual emissions. Mitigation measures and initial abatement potentials were sourced from the UK Marginal Abatement Cost Curve, which allowed emissions to be reduced mostly through improvements in efficiency without compromising productivity. Area footprints were calculated for production, with and without the offset area needed to achieve Net Zero to highlight implications for land use.

Results
Carbon footprints ranged from 13.0-54.4 kg CO_2e kg^{-1} deadweight (DW) beef and 15.5-49.9 kg CO_2e kg^{-1} DW sheep. Baseline area footprints ranged from 28.4-841.5 m^2 kg^{-1} DW beef and 52.2-319.7 m^2 kg^{-1} DW sheep. Emission reductions following the implementation of mitigation measures averaged 28% across all farms. The woodland needed to offset the remaining emissions to achieve Net Zero ranged from 8-85% of farm area. However, it is important to note the Net Zero target is not at a farm level, so these trees do not necessarily have to be planted on farm. The apparent area efficiency decreased when offset area was accounted for, however, the ranking of farms was largely unaffected. Mitigation scenarios rely on several assumptions and these must be refined to accurately inform Net Zero pathways.

Conclusions
Our modelling showed that even after implementation of ambitious mitigation, large-scale land use change will be required to achieve Net Zero. However, this reform should not lead to displacement of production to less efficient systems, be they at home or abroad.

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137

Can yerba-mate extract mitigate methane emissions from beef cattle?

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Application
Yerba-mate extract, used as feed additive, should modify the fermentation profile in the rumen, reducing the methane emissions from ruminants.

Introduction
Plant extracts have been studied as alternatives to the use of ionophores aiming to alter the ruminal fermentative profile and the rumen ecology and consequently reducing methane emissions by ruminants. Yerba mate is a common plant in the southern region of South America and is characterized by having high levels of secondary compounds, as polyphenols, xanthines, in addition to alkaloids and flavonoids. The objective of this study was to evaluate the effect of inclusion of yerba-mate extract (YME) in diets of Nellore cattle on methanogenesis.

Materials and methods
Eight rumen-cannulated Nellore steers (initial BW = 402 ± 32 kg) were housed in individual pens with free access to water and feed. Four diets were formulated for the maintenance, with forage:concentrate ratio of 70:30 and 104 g of crude protein (CP) and 659 g of total digestible nutrients (TDN) per kg of dry matter (DM), differing in four levels of YME (0, 5, 10 and 20 g per kg of DM). The experimental design was a replicated contemporary Latin Square, with the four levels of YME considered as treatments. The experimental unit was the animal within each Latin square, comprising 32 experimental units. Each period comprised 21 days (14 days of adaptation and 7 days of collections). The SF_6 tracer gas technique was used to measure methane (CH_4) emissions, as described by Johnson and Johnson (1995). CH_4 collections were taken daily for five days in each period, from animals previously adapted to the collection apparatus. CH_4 and SF_6 were determined by gas chromatography and emissions were estimated as described by Méo-Filho et al. (2020). Statistical analysis were carried out testing the normality of the residues (Shapiro-Wilk) and variables were analyzed using mixed models considering the fixed effects of treatments, square and period within the squares and the random effects of animal within the squares. P-values for linear and quadratic effects were determined.

Results
Although methane emissions have been expressed in five different ways no linear or quadratic effects were detected ($P > 0.05$). CH_4 emissions varied from 230 to 238 (SEM = 8.9) g/animal/day, from 30.6 to 31.0 (SEM = 0.94) g/kg DMI, from 215 to 409 (SEM = 87) g/kg ADG and from 0.50 to0.51 (SEM = 0.15) g/kg BW. From 9.5 to 9.6% (SEM = 0.28) of GE were converted to CH_4.

Conclusions
Yerba mate extract was not efficient in mitigating methane emitted by Nellore beef cattle.

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138

Helping farmers navigate the green economy: A data-driven blueprint for net zero beef

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Application
This study showed that analysing performance data to identify the optimal age at slaughter improved economic returns whilst reducing greenhouse gas emissions (GHGe) from beef cattle.

Introduction
Reducing carbon net zero is a clear priority, with beef farmers under significant scrutiny from food system stakeholders. Tools are available to assess GHGe, yet adoption is low and producers are not currently financially incentivised to change management practices. This study used cattle performance data from a commercial beef operation to retrospectively identify the optimal age and weight at slaughter to maximise profit and reduce enteric methane (CH_4) emissions at the individual animal and herd level, compared to actual management on farm.

Materials and methods
Performance data, including age at farm arrival and slaughter; sex; breed; days spent on pasture; entry and staged liveweight; carcass weight (CW); killing out percentage; conformation score and fat grade were sourced from 777 growing and finishing cattle at the ABP Bromstead farm for the period between July 2017-June 2020. Feed efficiency was measured using a GrowSafe feeder and used to model individual animal lifetime growth and daily feed intake. Enteric CH_4 emissions were calculated based on feed intake, DLWG and ration formulation. Matlab was used to model expected changes in lifetime costs, revenue and profitability allowed identification of the optimum age at slaughter. Economic parameters were executed to gross margin level and aggregated to provide each animals lifetime profit profile (£/head). This methodology identified cattle ages and weights at which gross margins were maximised (single-cycle optimal management) and lifetime profit maximised in perpetuity (multi-cycle optimal management).

Results
Optimal management using a multi-cycle approach generated an extra £339 per head (a 5% profit gain) compared to optimised management in a single cycle. When comparing optimal multi-cycle management to actual on-farm performance, an average sustainable profit gain of 45% was expected (£2278 per head in perpetuity). Concurrently, enteric CH_4 emission intensity per kg beef CW was reduced by 28% (single-cycle) or 32% (multi-cycle) under optimal management. When presented to beef focus groups, producers were excited about the opportunities that the results offered to improve operational performance, however, they highlighted concerns over a lack of knowledge and understanding regarding data collection for net zero.

Conclusions
Collecting and analysing cattle performance data that facilitate optimised management decisions at the individual animal level had significant benefits in terms of improving profitability whilst reducing GHGe. The great opportunity facing the beef industry is to identify and adopt on-farm practices and technologies that facilitate optimal management and to capture performance data such that the economic and environmental efficiencies that we have highlighted here can be gained.

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139

Beef cattle performance and enteric methane emissions, comparison between unfertilized mixed sward vs fertilized permanent pasture

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Application
Although there was no difference in enteric methane (EME) emissions from beef cattle raised on an unfertilized mix sward compared to a fertilized permanent pasture. There is a saving in fertilizer use, and costs whilst maintaining animal performance. Still, environmental benefits with less N being applied and nitrous oxide released into the atmosphere.

Introduction
Most of the UK's agricultural sector emissions is methane arising from livestock. How this emission can be minimised while also maintaining global food and nutrition security remains a challenge (UKRI, 2022). Thus, it is relevant the study different beef cattle production pasture systems, looking at the performance and emissions obtained from each management. This study aimed to investigate if cattle raised on different types of pastures, i.e., fertilized PP vs. unfertilised mixed sward composed of high sugar perennial ryegrass and white clover (RG-WC), express different performance and enteric methane emission.

Materials and methods
The experiment was carried out during two grazing seasons (2019 and 2021) at the Rothamsted Research North Wyke Farm Platform (UK). Two types of pasture corresponded to the treatments: PP, dominated by perennial ryegrass (PRG; *Lolium perenne* L.) and *Agrostis stolonifera* L. receiving 200 kg N/ha/year (April to August); RG-WC, comprised PRG (cv. AberMagic), and white clover (*Trifolium repens* L.) (target soil cover 70:30, respectively). Over the two experimental periods, one hundred fourteen beef steers and heifers (Stabilizer breed), initial live-weight (LW) 475 ± 50 kg, were evaluated. In each experimental period, two samplings were deployed to measure the EME ($n = 32$) using the sulphur hexafluoride gas (SF_6) tracer technique (Lambert et al., 2014). Animals were weighed every 30 days. Statistical analysis (Genstat 21) included treatment effects (pasture type), period (year) and interaction treatments X period as fixed effects, and sex as a random effect in the model. The treatment effect was considered significant at $p < 0.05$. Mean separation was performed with the F-test.

Results
No significant differences were identified ($p > 0.05$) between the PP and RG-WC treatments for the final live weight (FLW), 556.4 vs. 556.3 kg, average daily gain (ADG), 0.83 vs. 0.83 kg/day, and regarding the EME, 205.0 vs. 195.2 g/day, concerning the ADG, 202.4 vs. 215.2 g CH4/kg ADG, or LW, 0.38 vs. 0.36 g CH4/kg LW, respectively.

Conclusions
The performance and EME did not differ in beef cattle raised on a fertilized permanent pasture or an unfertilised mixed sward with high sugar PRG and white clover.

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140

Herbage production and growth performance of late-maturing suckler-bred steers grazing grass- clover or multi-species swards

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Application
Herbage production and animal intake and growth achieved by multi-species swards was similar to that of grass-clover swards.

Introduction
Agriculture has an obligation under EU legislation to reduce its environmental impact. The potential benefits of including nitrogen-fixing white clover in perennial-ryegrass swards are well established in terms of herbage production, feeding value and animal performance. The inclusion of additional herbage species in swards may offer further advantages. The objective of this study was to determine the herbage yield, intake and growth of steers grazing grass-clover or multi-species swards.

Materials and methods
Suckler-bred Charolais yearling steers ($n = 72$; 395 kg, initial weight), previously offered grass silage ad libitum plus 2 kg of concentrate daily, were blocked on weight and genetic merit and assigned to one of six grazing groups, which were randomly allocated to one of two pasture types: (i) grass-clover; perennial ryegrass and white clover or (ii) multi-species; perennial ryegrass, timothy, white clover, red clover, chicory and plantain, sown the previous year. Total land area (27 ha) was divided into six farmlets ($n = 3$/treatment) comprised of paddocks, which were rotationally grazed (target sward height 5.5cm) for 195 days. Steers grazed 13.5 ha from 5 April (turnout) until late-July, while the remaining area was harvested for silage; all the area was grazed subsequently. Chemical nitrogen fertilizer was not applied to the grazing area of either pasture type. Herbage surplus to grazing requirements was removed as baled silage. Pre and post-grazing sward height (rising platemeter), herbage mass above 4 cm (lawnmower cuts) and estimated dry matter intake (herbage disappearance adjusted for growth during paddock residency) were determined. Steers were weighed pre- and 48-h post-turnout and fortnightly thereafter; the 48-h post-turnout weight was used to calculate average daily gain at pasture. Ultrasonic measures of fat and muscle depth were measured at the start, middle and end of the grazing season. Data were statistically analysed using ANOVA with the fixed effect of pasture type in the model. The experimental unit was grazing group.

Results
Mean (S.D.) pre-grazing herbage mass was 1854 (788.7) and 1761 (762.2) kg DM/ha, and post-grazing sward height was 5.6 (0.69) and 5.2 (0.77) cm for grass-clover and multi-species, respectively. Herbage production (12770 vs. 12782 kg DM/ha), steer daily dry matter intake (8.12 vs. 7.75 kg), daily live weight gain (1.18 vs. 1.17 kg) and ultrasonic measures of body composition did not differ ($P > 0.05$) between multi-species and grass-clover swards during the grazing season.

Conclusions
Under the conditions of this experiment, herbage production and animal intake and growth during a 195 day grazing season was similar for multi-species and grass-clover swards.

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141

Influence of ethanolic extract of Urochloa brizantha on in vitro rumen fermentation

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Application
Development of extract rich in plant secondary metabolites (PSM) such as saponins and tannins with potential to reduce methane emission.

Introduction
Due to the importance of the livestock sector as a contributor to GHG emissions, several strategies to mitigate methane (CH_4) through the modulation of ruminal fermentation have been studied. Plant extracts have several secondary metabolites (PSM), such as saponins and tannins, that could be used as potential ‘‘natural” alternatives to ‘‘chemical” additives in the favourable modulation of rumen fermentation (Ku-Vera et al., 2020). However, the majority of biomass of these are used in human food and has higher prices. In Brazil, beef cattle are predominantly pasture-based and the genus *Urochloa* corresponds to 85% of cultivated pastures. Therefore, this study aimed to test the hypothesis that *U. brizantha* ethanolic extract (UEE) has PSM with the potential to reduce methane emission.

Materials and methods
The treatments corresponded to increasing levels (0, 75, 150, 225 and 300 mg/kg dry matter DM) of UEE inclusion in substrate composed of 30% of concentrate and 70% of corn silage. The *in vitro* gas production measurements were made at 0, 4, 8, 12, 16, 20, 24 h post-inoculation using the semi-automatic technique with a pressure transducer. At each measurement, 1.5 mL of the gases were collected for methane determination by the chromatographic method. After 24h, the flasks were placed in containers with ice to interrupt the fermentation process. Then, samples of the rumen liquid contained in the bottle were collected for determination of short chain fatty acids (SCFA) and ammonia nitrogen ($N\text{-}NH_3$). Results were interpreted by regression analysis as a function of inclusion levels of UEE in the diet by SAS 9.4 program at the 5% significance level.

Results
No differences were observed ($P > 0.05$) between treatments regarding gross methane production (6.72, 6.06, 6.98, 7.89 and 7.34 mL CH_4/DM); or as methane produced by degraded DM (DDM) (14.51, 12.95, 15.58, 18.76 mL CH_4/DDM, respectively for doses 0, 75, 150, 225 and 300 mg/kg DM). Also there was no difference ($P > 0.05$) in total SCFA production (ranging from 5.0 to 5.6 mM) or in $N\text{-}NH_3$ content (ranging from 15.2 to 19.1 mg/dL).

Conclusions
No significant effects were identified following the inclusion of UEE as a methane mitigator. The use of dry extract in order to concentrate the PSM could be more effective strategy and warrants investigation.

Acknowledgments
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142 (Invited Speaker)

Innovations for the Beef Sector: An academics perspective on challenges and successful adoption

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Climate change is the defining issue of our time. In response, the UK Government has set an ambitious target to achieve net-zero Greenhouse Gas (GHG) emissions by 2050. As a result, there is growing urgency for all sectors, including agriculture, to reduce their GHG emissions. The development and successful adoption of data-driven solutions offers significant opportunities for improving the efficiency of the beef sector – with aligned carbon-reduction benefits. It is imperative that these solutions are supported by a robust evidence base and are presented in forms that can be easily adopted by farmers and that are acceptable to consumers. This session aims to share the highs and lows from recent experience in the development and application of Precision Livestock Farming (PLF) solutions for continuous, automated and real-time monitoring of livestock. The session will also explore, from an academic's perspective, the challenges and opportunities of working in complex multidisciplinary collaborations, focussed on developing novel and disruptive technologies, specifically for the beef sector (including beef from dairy). This session aims to inform scientists, innovators, producers, funders and policy makers in leading new activities which accelerate the uptake of new technologies and systems.

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143 (Invited Speaker)

Accelerating the adoption of livestock innovation

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Presentation summary
In this session you will hear from those who are successfully developing and exploiting new innovation in livestock production. Highlight relevant funding schemes and explore new opportunities to accelerate adoption, remove innovation barriers, and enable us to meet current UK needs and challenges at pace.
With a focus on the critical success paths to commercialising research and the steps that are critical to driving adoption in the livestock sector including value proposition development, social engagement, environmental issues, user experience and adoption.
How can the whole supply chain work together and the importance of the wider benefit of technology to encourage influencers in the supply chain to support new technology.
Finally some of the challenges that the UK faces in design, commercialisation, funding and development, and how to over come these.
This session will inform scientists and innovators, end-users of innovation in the livestock industry, funders and policy makers in leading new activities which accelerate the uptake of new technologies and systems.

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144

Using Efficiency-Corrected quantitative PCR to assess risk of respiratory disease in feedlot cattle

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Application
Bovine Respiratory Disease (BRD) is a multifactorial syndrome associated with a number of bacterial and viral agents causing severe, and sometimes fatal, respiratory disease in cattle (Fernández et al., 2020). It is the leading cause of disease and death in feedlot populations with a global economic impact of over $3 billion/year (DeDonder and Apley, 2015), accounting for more than 80% of morbidity and mortality in feedlot operations in Australia (Blakebrough-Hall et al., 2020). Accurate and timely PCR-based diagnostics could reduce production losses and allow precision application of antimicrobial therapy by identifying individuals or cohorts at high risk of BRD.

Introduction
To investigate if BRD risk could be associated with bacterial and viral prevalence and load, ten bacterial and viral agents associated with BRD in feedlot: *Histophilus somni, Mannheimia haemolytica, Mycoplasma bovis, Pasteurella multocida, Trueperella* pyogenes, Bovine Coronavirus (BCoV), Bovine Viral Diarrhoea Virus (BVDV), Bovine Respiratory Syncytial Virus (BRSV), Bovine Parainfluenza Virus 3 (BPIV-3), and Bovine Alpha Herpesvirus 1 (BoAHV-1) were analysed in feedlot induction and hospital pen cattle.

Materials and methods
Nasal swabs were collected from 1167 induction and 144 and hospital pen cattle at four locations across New South Wales, Australia, between May and August 2021. Multiplex and single-plex efficiency-corrected PCR quantification (Ruijter et al., 2021) was used to determine prevalence and load with Bayesian Network modelling used to interrogate relationships between pathogen load and combination, as well as production and carcass parameters using Netica® software. Sensitivity analysis determined key relationships for risk of disease progression in induction cohorts or disease in hospital cattle.

Results
H. somni, M. haemolytica, M. bovis, P. multocida and T. pyogenes showed highest prevalence across all locations, with concentrations increasing between Day 0 and Day 14 of feedlot induction. BoAHV1 showed greatest prevalence and load with BCoV and BPIV3 only detected in 2/4 locations. BRSV and BVDV were not detected at any location. *M. bovis* was rarely detected at feedlot induction but was significantly increased in prevalence at Day 14 in 3/4 locations tested. Bayesian Network modelling and sensitivity analysis of induction cattle showed that disease risk, both BRD and other ailments, was associated with location and agent combination, with agent combination exerting greatest influence in hospital animals. A two-panel multiplex analysis provided greatest efficacy for widespread screening.

Conclusions
Prevalence and combination of BRD-associated bacterial and viral agents exerted greatest risk for progression and, or diagnosis with BRD in both induction and hospital cohorts. The ability to deliver syndromic screening for BRD pathogens using EC-corrected multiplex PCR panels presents a new technological approach for the investigation, analysis, identification management and treatment of BRD.

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145

The occurrence of near misses and farmers' perceptions of safety when working with cattle

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Application
An improved understanding of farmers perception of safety on farm can be used to develop targeted knowledge transfer and health and safety education, in turn improving on farm safety.

Introduction
Cattle farming requires humans to interact with large and potentially dangerous cattle. A survey to assess safety with cattle was designed with input from experts from scientific, agricultural and Health and Safety (H&S) backgrounds. Subjects were also asked about 'near misses' where either no injury or a minor injury occurred when working cattle.

Materials and methods
The survey was E-mailed to 15,500 registered cattle owners in Northern Ireland (NI) and advertised on social media and the local farming press. Three hundred farmers responded to the survey and answered 63 questions on: 'Personal information' such as sex, and age; 'Farm characteristics', further subdivided in to Dairy, Suckler and Bull beef; 'H&S awareness', how safe the respondent felt on farm and how they sourced H&S information; 'Dangerous occurrences', the number and type of near misses which had occurred; and 'Genetics and temperament', the respondents perception of associations between genotype and temperament. Data were analysed using R and associations were calculated using chi squared analysis.

Results
Respondents were predominantly male and ranged from 29 to 99 years of age. Most respondents managed a suckler beef cow herd. There was no association between cattle enterprise and age group. The most popular source of H&S advice was Radio / TV / Magazines and Newspapers. Respondents who had accessed more than one source of advice were more likely to invest in infrastructure ($\chi 2 = 5.85$, df = 1, $P = 0.016$). The majority of respondents ($n = 260$) had not attended H&S training. Contractors were employed for some management with farmers who employed contractors for feet/hoof trimming or castration perceiving the activity to be safer ($\chi 2 = 33.9$, df = 3, $P < 0.001$ and $\chi 2 = 9.97$, df = 4, $P = 0.041$ respectively). There were 55 respondents who cited 1 or more near misses. Collectively the 55 respondents reported 342 near misses, 199 of which took place while working alone. Respondents felt that the farmers' handling skills, human animal interactions, facilities and the animals' genetics were the most important factors influencing levels of aggression.

Conclusions
The findings demonstrate that farmers perceive the use of specialist contractors, improved infrastructure and animal genetics can impact how safe farmers feel when working with cattle. The outcomes will be used to improve our understanding in NI cattle farms health and safety conditions, to make evidence-based policy, to improve farmers' awareness of safety on cattle farms.

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146

The welfare of housed and grazing beef cattle using Qualitative Behaviour Assessment (QBA)

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Application
There appears to be less social/behavioural cohesion for housed cattle. Thus, the behavioural differences very much support the need for enrichment within beef cattle sheds.

Introduction
Decisions regarding the extent to which cattle are housed or on pasture are central to farm management and impactful on the societal sustainability of beef systems. The behavioural domain of animal welfare can be studied with the Qualitative Behaviour Assessment (QBA) (Wemelsfelder, 2008).

Materials and methods
Two herds of beef cattle (30 heads each) were directly compared from weaning in October 2020 to July 2021 across numerous welfare indicators (i.e., physical health, hormones and behaviour). However, here we are only presenting the behavioural study. One herd (''HH'') was housed this entire time, and the other (''HG'') was housed until April before being turned out onto pasture. On a weekly basis, QBA was conducted for each herd. Cattle were observed for 10 minutes in their 'home' environment (e.g. housing or pasture) before being scored on a 125mm visual analogue scale across 20 terms, based on the prevalence and intensity of the relevant factor: Active, Agitated, Apathetic,

Bored, Calm, Content, Distressed, Fearful, Friendly, Frustrated, Happy, Indifferent, Inquisitive, Irritable, Lively, Playful, Positively occupied, Relaxed, Sociable and Uneasy.

Results
During winter, the overall behaviour of both herds was similar, reflecting their comparable housing. PC1 and PC2 accounted for 51.4% of the variance in this season. PC1 could be defined as 'mood' due to a strong positive association with positive mood terms, and a negative association with negative mood terms. PC2 was more associated with levels of arousal and was associated positively with relatively sedate behaviours (e.g. 'Bored' and 'Calm') and negatively with more aroused terms. Across PC1 this difference was significant ($p = 0.013$) but not in PC2. Summer QBA results showed a notable difference in the overall behaviour profiles of the two groups. PC1 and PC2 accounted for 51.3% of the variance in this stage. The HG herd (grazing) were highly associated with descriptors such as "Content", "Happy", "Sociable", and "Positively Occupied" an had relatively consistent scores associated with positive terms such as "Sociable" and "Happy". Meanwhile, the HH herd's behaviour was far more varied and associated with more neutral and negative terms such as "Bored" and "Indifferent". Herds differed across both PC1 ($p = 0.004$) and PC2 ($p < 0.001$).

Conclusions
Results supported grazing as a better management system in terms of welfare, predominantly due to a greater prevalence of positive behaviour.

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147

Histological characterisation of the caecal mucosa of cattle fed diets with no cereal, moderate cereal, or high cereal inclusions

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Application
Assess and measure differences in the caecal pathology of cattle from different fattening systems.

Introduction
In many farming systems, diets containing large proportions of rapidly degradable carbohydrates as high-starch cereal grains are fed to meet energy requirements for efficient production. However, the over-supply of, or rapid transition to, high-starch diets can result in digestive disease (ruminal acidosis and sub-acute ruminal acidosis). The challenge posed by such diets cause anatomic, microbial, proteomic, and transcriptomic gastrointestinal tract (GIT) change, along with variable systemic effects. These changes have been well characterised in the proximal GIT; however, there is a paucity of data from cattle describing the impact in the distal GIT. This study aimed to characterise the morphology and immune cell distribution in the caecal mucosa of cattle offered commercial diets containing variable grain inclusions.

Materials and methods
Caecal tissue was obtained immediately post-slaughter from 30 commercial beef fattening cattle from 3 different fattening systems offering diets containing grain inclusions of 0%, 50%, or 90% ($n = 10$ each group) of the total ration. Tissue samples were processed and stained with conventional (Alcian Blue and H&E) and immunogenic (CD20, CD3, IBA1, MAC387, MPO, and TUNEL) stains before being digitally scanned (MoticEasyScan Infinity 60) and examined via the QuPath digital pathology software. All data were analysed using R version 4.2.0. Non-continuous, ordinal data were mean corrected, and all data was subject to the assessment of normality by the Shapiro-Wilk Test. The effect of the farming system on each variable was assessed using a one-way ANOVA followed by a Tukey's HSD test. The treatment effect was considered significant at $p < 0.05$.

Results
Morphological characterisation of the caecal mucosa based on a pathological score ranging from 1 (minor) to 3 (severe) revealed a reduction in mucosal integrity, pitting of the mucosal surface and loss of Crypt of Lieberkühn integrity, with increasing dietary grain ($p = 0.0254$). No difference in glandular mucosa thickness ($p = 0.7050$) or combined non-glandular mucosa and submucosa thickness ($p = 0.1110$) was observed between groups. The diameter of the Crypts of Lieberkühn was narrower in the 0% dietary grain group compared with the 50% and 90% groups ($p < 0.0001$). The proportion of CD3+ lymphocytes and antigen-presenting cells (IBA1+) in the caecal mucosa were significantly higher in grain-fed animals ($p < 0.0001$ and $p < 0.0001$, respectively). Whereas the proportion of myeloperoxidase positively

staining cells and TUNEL positively staining pixels were significantly higher in cattle fed the 90% grain inclusion diet only ($p = 0.0007$ and $p = 0.0289$, respectively).

Conclusions
We conclude that feeding concentrate during the fattening period can result in adverse pathological changes in the caecum.

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148

Molecular detection of Trypanosoma brucei infection in Nigerian cattle

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Application
This study provides information on the effectiveness of trypanosomosis control measures and also will facilitate future monitoring and control of Trypanosoma brucei infection. The results obtained will facilitate treatment of cattle herds as the quantity of beef derivable from infected animals, even at asymptomatic chronic levels may be drastically reduced from muscle wastage.

Introduction
The infection of Trypanosoma brucei is a major constraint to cattle production in the southern part of Nigeria which is tse-tse fly infested (Okwelum et al., 2014). Apart from loss in production of livestock, T. brucei infection has zoonotic importance as the causative agents of human trypanosomosis (sleeping sickness) are T. brucei rhodesiense and T. brucei gambiense (Picozzi et al., 2002). Rapidly identifying animal reservoirs for human infective trypanosomes are of public health importance. As spreading of sleeping sickness is also closely related to the movement of cattle populations, regular screening of livestock is advocated (Ferve et al., 2001). This study therefore, investigated the true prevalence of T. brucei infection and its effects on haematological indices of Nigerian cattle as this plays a role both directly and indirectly on the improvements of the rural farm families.

Materials and methods
Blood sample was collected from 180 cattle from the sedentary herds among the rural farm families where each family own 1-2 cattle from the middle belt to the southern Nigeria. Trade cattle in the north arrive daily from the neighbouring countries for slaughter were not screened. Ages ranged from 1-4 years and the breeds were Muturu, N'Dama and Keteku. DNA was extracted from the blood using Norgen's Blood Genomic DNA Isolation kit. PCR was adopted for the prevalence studies with the T. brucei specific primers used in the PCR protocol while amplifications as viewed on the Gel Documentation was considered positive (infected) and no amplification was considered negative (un-infected). Haematological analysis was carried out using Auto-haemo-Analyser. ANOVA in a Generalised Linear Model (GLM) was used for data analysis with SAS 9.1 package.

Results
The prevalence of T. brucei infection was 96.66%. There were significant ($p < 0.05$) differences between PCV and Monocyte Percentage of T. brucei infected and un-infected cattle.

Conclusions
This study concluded that the prevalence rate of T. brucei infection was high and this has both epidemiological and economic importance.

Acknowledgments
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149

Evaluation of genetic progress for survival and reproductive traits of cross-bred beef cattle in UK

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Application
Provides insights for top bulls selection for beef production by beef producing farmers and beef industries.

Introduction
Genomic evaluation for different traits of beef cattle improves the accuracy of selection. This study aims to evaluate the genetic progress of survival and reproductive traits of cross-bred beef cattle in UK.

Materials and methods
The traits include interval between first and second parities (CI12), age at first calving (AFC), docility, calf size, calf-vigour, survival traits (calf survival at day 30, 90 and 180), and still birth at zero and 48 hours. A total of 1,539,151 animals were in the pedigree, of which 704,892 and 110,903 animals having phenotypes and genotypes, respectively, were used as starting materials. These data originated from the Beef Efficiency Scheme (BES) operated by Scottish Government from 2016 to 2021 whereby farmers opted in to receive farm payments and genotyped a proportion of their beef herd. The pedigree data was dated back to the 1860s, whereas the phenotype data was after 2012. Quality of the genomic data was evaluated using 90% call rate (at animal and marker level) and 0.5% MAF that resulted in 39,554 SNP markers after filtration for the downstream analysis. Mixed linear animal model in a single-step GBLUP (ssGBLUP) approach was employed to obtain genomic estimated breeding values (GEBVs). Depending on the traits, calving season, calving ease, sex, parity and birth type were fitted as fixed effects, and heterosis and recombination of the animals as covariate effects in the model. The variance components and heritabilities were estimated using ASReml and the GEBVs were estimated using Mix99 packages.

Results
Moderate to high heritability estimates were obtained: 0.05 (Surv30d), 0.07 (Surv90d), 0.08 (Surv180d), 0.11 (docility), 0.33 (calf-vigour), 0.39 (calf size), 0.38 (stillbirth0hr), 0.44 (stillbirth48hrs), 0.41 (AFC) and 0.43 (CI12). The genetic trend, GEBV, was summarised every year starting from 1951 to 2021. Hence, the average change of GEBVs over years were estimated to be 0.001% for Surv30d, -0.003% for surv90, 0.3% for surv180, 0.004% for docility, 0.01% for calf-vigour, 0.1% for calf size, -0.001% for stillbirth0hr, -0.001% for stillbirth48hrs and 3.9% for CI. The highest average change of GEBVs over years was observed for AFC, 1.38 ± 12.19 days improvement per year.

Conclusions
The overall trend of GEBVs over years shows that a remarkable improvement has been achieved in UK crossbred beef herds after the 1990s that could be associated with the implementation of structured breeding programs and better phenotyping afterwards. Emergence of the genomic era has brought the introduction of modern breeding tools in the breeding programs which has created a usable reference population for genomic prediction based on Scottish beef cattle.

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150 (Invited Speaker)

How to manage liquid feeding to ensure health and welfare of dairy calves?

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Colostrum is crucial for ensuring the health and survival of calves. Successful colostrum management relies on four main criteria including the timeliness, the quality, the quantity, and the cleanliness. Although the protein fraction of colostrum and its immune components have been extensively studied in the first days following parturition, knowledge related to the changes occurring in relation to fat composition is

limited. From a theological stance, elevated concentrations of specific fatty acids in colostrum compared with transition and mature milk may indicate a biological need of the neonatal calf.
In artificial rearing systems, dairy calves are commonly fed restricted levels of milk (10% of birth BW as volume) leading to poor growth rates, whereas in natural systems, calves voluntarily consume about 20% birth BW. Feeding low milk volumes compromises the health and welfare of calves and can negatively impact subsequent lactation performance. Leal et al. (2022) showed that calves fed 8.0L/d of milk replacer (MR) in the preweaning phase yielded more protein and fat-corrected milk in the first and second lactation than calves fed 4.0L/d. In this study, a specific metabolic pathway was expressed differently in the preweaning phase was still different in the first lactation, thus suggesting long-lasting metabolic differences. However, feeding elevated planes of milk to replacement heifers raises concerns regarding the type of liquid feed and the weaning transition management.
Whole milk from the tank has an optimal macronutrient composition but its management on farm can be practically challenging. Alternatively, feeding pasteurized waste milk is common in large dairy operations but exposes the calf to antimicrobials and the composition may be highly variable. In contrast, feeding MR to calves provides consistent nutrient supply; however, the quality is not uniform across commercial products. Indeed, MR usually contains lower levels of fat and higher levels of lactose or protein than WM, which modulates the metabolic profile of young calves. Other components such as the fat composition should also be considered.
Commercially raised dairy calves only have access to milk for 6 to 10wks after birth; while under natural conditions, calves are weaned around 8 to 12mo of age. Shortening the preweaning period lowers costs associated with liquid feed, however, calves may not be physiologically ready to efficiently digest solid feed, resulting in poor post-weaning growth rates. Implementing adequate weaning transition strategies is of utmost importance in calves fed high milk planes as their preweaning starter feed intakes are usually half that of calves fed restricted levels of milk from birth. Research shows that the weaning transition should not start earlier than 8wks of age, and implementing smooth transitions allows maintaining high growth rates. Alternatively, providing a high-fat extruded pellet mixed with a starter feed increased metabolizable energy intakes resulting enhanced growth postweaning.
Current trends in calf nutrition research show the importance of providing sufficient nutrients to calves in early life to improve welfare and future productive performance.

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151

The effect of supplementary milk withdrawal on piglet pre-weaning creep consumption

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Application
Withdrawal of supplementary milk in the final week prior to weaning reduces the utilisation of economically expensive milk powder. Encouraging creep consumption by withdrawing supplementary milk has an immediate economic benefit, and increased creep consumption may improve post-weaning performance.

Introduction
Utilisation of supplementary milk (SM) pre-weaning is a strategy to reduce mortality , particularly if there are supernumerary piglets in relation to functional teats (Kobek-Kjeldager et al., 2020). Usage of SM increases throughout the suckling period. Creep-feeding pre-weaning prepares piglets for consuming solid feed post-weaning, with high consumers having higher average daily gain (ADG) post-weaning compared to low consumers (Icely et al., 2022). This study aimed to determine whether withdrawing SM provision seven days prior to weaning would result in higher creep consumption.

Materials and methods
Twenty-eight litters in a single farrowing batch had access to SM from birth and creep from 14 days prior to weaning (wn-14). Seven days prior to weaning (wn-7), all piglets were weighed and SM was removed from 14 of the litters (Early). Access to SM for the remaining litters (Control) was maintained until one day prior to weaning (25 days old). Treatments were allocated according to average piglet weight and number of piglets/litter at wn-7. Supplementary milk was recorded on a whole-batch basis, creep on a litter basis. Piglets were weighed at weaning and remaining creep recorded. Litter ADG, creep consumption, sow P2 backfat and feed intake were analysed by one-way ANOVA (Genstat 20th edition).

Results
At wn-7, number of piglets/litter was similar between Early and Control (14.50 Early, 14.64 Control), as was average piglet weight (6.40 kg Early, 6.42 kg Control). Creep consumption of Early litters was 2.57 kg/litter greater than Control litters (5.70 kg *vs* 3.13 kg, $P = 0.006$). Average SM dry matter (DM) consumption for Control litters from wn-7 to weaning was 3.90 kg, resulting in greater combined SM and creep DM consumption for Control litters. At weaning, number of piglets/litter (14.43 Early, 14.57 Control) and average weaning weight (8.17 kg Early, 8.28 kg Control) were similar between Early and Control. Sow feed intake in the final week tended ($P = 0.084$) to be greater for Early litters, but there was no difference in overall sow feed intake or sow P2 loss over lactation.

Conclusions
Withdrawing supplementary milk seven days prior to weaning increased creep consumption with no adverse effects on mortality or performance, despite reduced supplementary dry matter consumption overall.

Acknowledgments
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152

The impact of plane of nutrition and ambient temperature on the energy utilisation, performance, health and behaviour of newborn dairy-bred bull calves

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Application
This study aimed to investigate how environmental temperatures representative of Northern Ireland impact calf performance, energy utilisation, health and behaviour of neonatal dairy calves. It also investigated the interaction between early life elevated nutrition and environmental temperature on these parameters and if elevated feed rates could mitigate the impact of cold temperatures.

Introduction
In the first few weeks of life dairy calves reared in Northern Ireland (NI) are often exposed to low environmental temperatures (Brown et al, 2021). Furthermore, calves on many NI dairy farms (approximately 50%) are offered less than 750 g/day milk replacer (MR) at 21 days of age (Brown et al, 2021). This study aimed to assess the impact of environmental temperatures regularly observed in Northern Ireland on calf performance, feed efficiency, health and welfare. Furthermore it aimed to assess the use of elevated milk replacer feed rates to mitigate the effects of cold stress.

Materials and methods
Nineteen Limousin and Aberdeen Angus dairy origin bull calves were placed in indirect calorimetry chambers from birth until 21 days of age. Calves were allocated at birth to one of 4 treatments in a 2 $\times$ 2 factorial design assessing MR feed allowance and environmental temperature: (1) a high feed allowance (1200 g/day) at 18 °C (18Hi), (2) a high feed allowance at 8 °C (8Hi), (3) a low feed allowance (600 g/d) at 18 °C (18Lo), or (4) a low feed allowance at 8 °C (8Lo). Calves were fed by individual teat bucket and offered ad lib access to water and solid feed. Calves were removed from the chambers on day 21 and were then group housed and offered milk replacer and solid feed from automatic feeders. Calves were weaned at 56 days of age and remained in the same group housing until the study ended at day 70. While in the chambers, live weight, health scores, rectal temperature, heart rate, skin temperature, calf activity and blood metabolite levels were measured. For 3 days in weeks 1 and 3, total faecal and urine collections were performed to measure energy and nitrogen balance alongside nutrient digestibility. During these periods, O_2, CO_2 and CH_4 were measured to calculate daily heat production by calves. After removal from the chambers, calf feed intake and performance were monitored daily and blood metabolites measured on the day of complete milk withdrawal (day 56).

Results
In the first 3 weeks of life calf feed intake (1064 vs 605 g/d; $p < 0.001$), performance (0.67 vs 0.45 kg/d; $p < 0.001$) and feed efficiency (0.75 vs 0.49 kg ADG/kg DMI; $p < 0.001$) were increased with increased feed allowance, however only performance in week 3 was increased (0.81 vs 0.30 kg/d; $p < 0.001$) by the higher environmental temperature. Health parameters were not affected by feed allowance or temperature, with the exception of faecal scores which were higher (indicating a poorer consistency) in high feed allowance calves in week 2 (0.77 vs 0.24; $p < 0.001$). Daily heat production and retained energy were not affected by temperature ($p = 0.239$ and $p = 0.141$, respectively), however in calves offered high feed allowances daily heat production (18.97 MJ/d vs 13.95 MJ/d; $p = 0.001$) and retained energy (2.25 MJ/d vs -2.31 MJ/d; $p = 0.009$) were increased when compared to low feed allowance. Calves offered low feed allowances had elevated β-hydroxybutyrate (0.088 vs 0.066 mmol/l; $p = 0.004$) and blood urea nitrogen (2.88 vs 2.22 mmol/l; $p < 0.001$), although no differences were observed in non-esterified fatty acids (NEFA) ($p = 0.225$). Calf skin temperature was greater in calves offered higher feed allowances (28.4 °C vs 23.4 °C; $p = 0.002$) and those housed at the greater environmental temperature (30.4 °C vs 23.4 °C; $p < 0.001$). A increase in lying time at the colder temperature was only observed at the lower feed allowance (19.5 hrs/day vs 18.9 hrs/day; $p = 0.03$).

Conclusions
Although an environmental temperature of 8 °C was not linked with differences in calf heat production, energy balance, blood metabolites, feed efficiency, or growth performance across the first 3 weeks of life, behavioural and metabolic adaptions were observed. Elevated feed rates of 1200 g/day increased calf performance, energy utilisation for growth and subsequent feed efficiency during the first 3 weeks of life when compared to traditional feed allowances of 600 g/d.

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153

Understanding how goat kids feed from a computerised ad libitum milk feeder

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Application
Quantifying how goat kids use *ad libitum* milk feeders can inform future research and on-farm management practices.

Introduction
Most dairy goat farmers use *ad libitum* milk machines providing unrestricted milk access to artificially reared goat kids (Anzuino et al., 2019; Belanger-Naud et al., 2021). However, kids' feeding behaviours may differ, affecting their welfare and productivity – yet no research has investigated kids' responses to these systems. The aim was to assess the individual and group milk feeding behaviour of dairy goat kids fed *ad libitum* milk.

Materials and methods
Individual milk intakes, number and duration of milk station visits were recorded for sixteen male dairy goat kids across two pens (one milk teat per pen) from weeks three to eight (weaning). Pen-level creep feed, hay, straw, and water intakes were measured from weeks two to ten. Average Daily Gain (ADG) was calculated from weekly weights. Repeated measures mixed models (random factor: kid ID; repeated: week; and fixed: pen and week*pen) analysed milk feeding behaviour (intake, number and duration). ADG was analysed by residual maximum likelihood analysis using kid ID and week as fixed factors, and explanatory variables as covariates. Spearman's rank correlations investigated the relationship between pen-level creep, hay, straw, and water intakes and age. Meal criterions were set by fitting a mixture of Gaussians to determine a threshold value to quantify meal frequency.

Results
Daily milk intake increased with age ($p < 0.001$; from 1619 ml (Wk4) to 2222 ml (Wk8)). Age did not significantly affect ADG ($p = 0.226$; weekly means 0.19–0.22 kg). Solid feed and water intakes during the milk-feeding period positively correlated with age ($p < 0.001$) and increased steeply post-weaning (64 g/day creep feed (Wk8) to 392 g/d (Wk9). On average each kid consumed 342.8 ± 20.7 ml (positively correlated with age $p < 0.001$) in 5.9 ± 0.28 daily meals (no age correlation $p = 0.666$) lasting 4.1 ± 0.22 min (no age correlation $p = 0.311$). There was no clear order of feeder access, 44% of meals were 'group meals' (>2 kids) with 74% of milk consumed during these.

Conclusions
Milk intake rises until weaning which coincides with a sudden increase in solid feed and water consumption. Number of daily milk meals was consistent over time but understanding the individual differences could inform further research on the relationship between behaviour and performance.

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154

Essential oils can reduce enteric methane emission from second cross lambs

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Application
Essential oils may reduce greenhouse gas emissions by reducing methane production in growing lambs.

Introduction
The concentration of methane in the atmosphere has increased rapidly since the pre-industrial era, and agriculture is one of the largest contributors to the global atmospheric methane pool. Australia must reduce 50% of its greenhouse gas (CHG) emissions by 2030 to comply with the Paris agreement. Therefore, strategies including nutritional interventions to mitigate enteric methane emission from ruminants, are urgently required to achieve this goal. This study investigated the methane mitigation potential of an essential oil blend.

Materials and methods
Sixteen 7–8 months old Poll Dorset × (Merino × Border Leicester) lambs were randomized to 2 different dietary treatment groups; control (n = 8) and 0.20 g/d essential oil blend (Agolin Switzerland, n = 8). The main active compounds of Agolin are food-grade and chemically-defined plant extracts, including coriander seed oil, eugenol, geranyl acetate and geraniol. The standard diet of the lambs contained 25% crushed barley grain, 25% crushed wheat grain, 25% oaten chaff and 25% lucerne chaff and was offered at 2 x maintenance. The animals were acclimatized to the control diet and feed additive for 18 days before the 12-day supplementation and measurement period. Enteric methane emission was measured using a hooded sniffer system (Guardian NG gas card) attached to the feed bins on days 1 to 4 (Period 1), 5 (Period 2) to 8 and 9 to 12 (Period 3). Body weight (BW) was measured using a walk-over scale every 6 days and daily feed dry matter intake (DMI) was calculated from feed offered and orts. Rumen fluid was obtained by stomach tube on days 6 and 12 and will be analysed for volatile fatty acid concentrations.

Results
Dietary Agolin supplementation had no significant effect on average daily gain (16 vs 130 g/d for control and Agolin, respectively, p = 0.11), DMI (1199 vs 1200 g/d, p = 0.99) or feed conversion efficiency (0.010 vs 0.102 g/g, p = 0.13). In contrast, dietary Agolin decreased methane production whether expressed on an extrapolated gross basis (36.1 vs 26.5 g/d, p = 0.008), a liveweight basis (0.933 vs 0.677 g/kg BW, p = 0.003) and feed intake basis (30.2 vs 20.2 g/kg DMI, p = 0.011). There were no significant main or interactive effects of period on methane production, indicating there was a consistent effect of Agolin across the treatment period.

Conclusions
These data clearly indicate that dietary essential oil supplementation as 0.20 g/d Agolin decreased methane production by 27% with no significant effect on growth performance. Therefore, Agolin offers a strategy to reduce CHG emissions from the livestock industries.

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155

Reducing the proportion of small lambs in a seasonal lamb production system

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Application
Reduction in the proportion of small lambs by use of sheep records and management strategies related to summer grazing, lamb finishing and lambing plan with respect to lamb fostering.

Introduction
Icelandic sheep production is highly seasonal, with indoor feeding from November until shortly after lambing in May, and slaughtering in September- October. The average lamb age at slaughter is around 145 days. Average carcass gain is 115 g/d, but 140–160 g/d on the best farms. The country average carcass weight was 17.4 kg in 2021, compared to around 15 kg in 2000. Still, the proportion of light lambs (<13 kg carcass weight) exceeds market requirement.

Materials and methods
Different possibilities for reducing the proportion of small lambs are evaluated, based on previous analysis (Sveinbjörnsson et al., 2020), data from the common sheep recording system and several lamb finishing trials.

Results
From year 2003, part of the subsidizes for sheep production in Iceland are only paid to farms participating in a common sheep recording system. The proportion of the winterfed sheep in the common database increased from 46% in year 2000 to 96% in year 2020. In the same period meat production per winterfed ewe increased at a four-fold rate compared to the 20-year period before that. This success is highly related to the emphasis on common registration and breeding work. Still, there is a great variation in lamb growth rates. Many examples show that some farmers are still not fully utilizing the data in their sheep records to select breeding stock and improve management.
Lamb finishing studies have shown that carcass growth of around or over 100 g/d can be sustained through October by grazing forage rape or other green forage crops. This is practiced by many farmers, especially in areas with slow growth rates on natural vegetation in late summer, and in general for the lighter part of the lamb stock.
Variability in weaning weight can be reduced by fostering. Surplus lambs can be kept for several days but fostering opportunities preferably need to be caught when the surrogate mother gives birth. Here, pregnancy scanning is very helpful. The lambing season can to a certain extent be planned already at pairing. Groups likely to provide surplus lambs should lamb slightly ahead of the groups likely to provide fostering opportunities. Examples of this are simulated in the present study.

Conclusions
The proportion of small lambs can be reduced by efficient use of sheep records and management strategies related to lamb fostering, summer grazing, lamb finishing and overall planning of the production system.

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156

Investigating nutritional strategies to replace Zinc Oxide in piglet diets

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Application
Removal of Zinc Oxide in a non-challenged situation could be achieved without modifying crude protein from diets. Reducing CP of starter diets did not impair overall efficiency.

Introduction
The use of Zinc Oxide (ZnO) in animal diets was banned by the EU in June 2022, with a 2-year extension for UK farmers. Pig producers face a challenge in seeking alternative methods, such as nutritional interventions to maintain piglet growth and health without increasing the use of antibiotics.

Materials and methods
720 piglets from 6 consecutive batches (120 per batch) were allocated to 1 of 6 dietary treatments at 28 days of age based on body weight and sex. The treatments consisted of control diets (20% CP starter 1 and starter 2) with 2500 mg/kg ZnO (T1), control diets without ZnO (T2), 16% CP starter 1 and starter 2 (T3), 18% CP starter 1 and starter 2 (T4), 16% CP starter 1 and 18% CP starter 2 (T5), 16% CP starter 1 and starter 2, and a 20% CP link diet (T6). All starter 1 diets were offered from day 0–13 post-weaning and starter 2 diets were offered from day 13–29 post-weaning except for T6. The T6 starter 2 diet was offered from day 13–22 post-weaning, and the link diet from day 22–29 post-weaning. Diets were offered *ad libitum* and formulated at 16.25 MJ/kg DE, 1.65% Lysine. All treatments were followed by a 17.5% CP grower diet offered until day 42 post-weaning. Pen feed intake was measured daily and body weight was recorded at weaning (day 0), day 13, 22, 29 and 42 post-weaning. Average daily gain (ADG), feed intake and feed conversion ratio (FCR) were calculated between days 0–13, 13–29, 29–42 and 0–42 post-weaning. Performance data were analysed by REML for fitting linear models using GenStat version 19. Dietary treatment was included as a fixed effect and batch was included as a random effect. Pen was considered the statistical unit.

Results
Diet significantly affected all performance parameters ($P < 0.05$) except for ADG from day 29–42 post-weaning ($P > 0.05$), and FCR from day 0–42 post-weaning ($P = 0.087$). T5 and T6 had worse FCR than T1 and T2 from day 0–13, and from day 13–22 (only T6), but not in the subsequent periods nor from day 0-42. There was no significant difference in any performance parameters between piglets given T1 or T2 ($P > .05$).

Conclusions
Piglet performance was not affected by the removal of ZnO in the T2 treatment compared with the T1 diet. In a non-challenging environment, the different strategies studied show potential to maintain performance in the absence of ZnO.

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157

The effect of stocking rate on enteric methane emission of Simmental calves grazing the salinized meadow in China arid region

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Application
Reduce enteric methane emission and increased dry matter grazing Simmental cattle with 1.33 calves/ha stocking rates in salinized meadows.

Introduction
Natural forage is the most important and cheapest source of forage (Bezabih et al., 2014). However, the quality and effectiveness of forage are affected by many factors, such as precipitation, growth state, quality, and stocking rate (Askar et al., 2014). Optimising the composition and quality of animal forages should help reduce CH4 emissions in the grazing system, thus combining sustainable animal production with environmental protection. The priority for mitigating climate change is to reduce GHGs from livestock production, which is also a priority for countries with grazing systems. Most ruminants in the Hexi Corridor of China are bred in grazing or mixed systems, thus requiring focus on how grazing practices can impact dry matter intake (DMI) and CH4 emissions.

Materials and methods
The study site (latitude 39.24°N, longitude 100.06°E, elevation about 1390 m above sea level) is located in Linze County, Gansu Province. Native pasture is widely developed in those ecoregions, and most of them had been cultivated into crop land, and are one of the important grazing systems in this area. The research used twenty-four 7 months male calve (175 ± 20 kg) (Simmental) which are widely distributed in this region. The experiment was based on a single factor random design that divided into three groups. The study sets 3 grazing rates (0.66 calve/ha, 1.33 calve/ha, 2.66 /ha), there are eight calves for each grazing rate. The first 30d were for adaptation to grazing land. After that, cattle were housed in separate spaces (each time a calve of each group had to be selected) for 3 days to feed fed from the grazing pasture. Respiratory measurement was performed in a ventilated open-circuit respiration chamber for 36 hours. The methane emissions were mea-

sured by infrared absorption-based gas CH4) analyzer. The method of bucking cage technique was used to estimate grazed DMI. The body weight (BW) of calf was measured every 10 days. Data were analyzed using One-Way ANOVA test using SPSS (20.0 edition).

Results
The DMI per daily of calves at 0.66 calve/ha and 2.66 calve/ha were 5.40 kg and 5.01 kg, respectively, both of which were significantly 14.15% and 20.27% lower than it at 1.33 calve/ha (6.29 kg) ($P < 0.05$). The enteric CH_4 emission per kg of DMI of calves at 1.33 calve/ha were 15.56% and 18.65% lower than that at 0.66 calve/ha and 2.66 calve/ha, respectively ($P < 0.05$). The enteric methane emission per kg BW was 0.60, 0.55, and 0.55 g/kg BW at the stocking rate of 0.66 calve/ha, 1.33 calve/ha, and 2.66 calve/ha, respectively, which were not significantly different ($P > 0.05$).

Conclusions
In a conclusion, an improved grazing management with the stocking rate of 1.33 calve/ha is recommended owing to the lowest enteric methane emissions and the highest DMI.

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158

Incorporation of *Malvaceae* into weaned piglet diets has sex dependant faecal microbiome effects

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Application
This research provides novel insights on the microbiome effect of *Malvaceae* inclusion, a potential mode of action for increases in faecal dry matter and IgA in piglets. This research aids the development of *Malvaceae* inclusion to improve piglet health.

Introduction
Piglets are susceptible to diseases at weaning which are typically treated with antibiotics and/or pharmaceutical ZnO. *Malvaceae* spp. have been shown to increase faecal dry matter and IgA in piglets (Ashton et al., 2022). The aim of this work was to assess the effects of *Malvaceae* on piglet faecal microbiomes.

Materials and methods
Ninety-six piglets at 28-days of age, weighing 7.63 ± 0.107 kg were weaned into 24 pens on a commercial farm. Piglets were offered diets following a 2 × 2 factorial design with 2.5 kg/tonne ZnO and 10 kg/tonne *Malvaceae* for 11-days, balanced by sex, sow and weaning weight. DNA was extracted from 76 individual 11-day faecal samples. Sequencing of 16s V3-V4 regions was performed. Bioinformatics analysis was performed in QIIME2 with the Silva 138.1 database. Features with frequencies above 10 and presence in over 10% of samples were retained. Alpha-diversity metrics Richness, Shannon entropy (Shannon's), Pielou's evenness and Faith phylogenetic diversity (Faith-PD) were analysed in R by type-3 ANOVA or Kruskal-Wallis. Jaccard's, Bray-Curtis and Weighted/Unweighted-unifrac beta-diversity distances were analysed by PERMANOVA. Multivariate differential abundance testing was performed in R using ANCOM v2.1.

Results
Pielou's evenness was not affected ($p > 0.050$). Zinc inclusion in no-*Malvaceae* diets increased richness ($p = 0.020$, 237 ± 18.6 vs 331 ± 20.8) in boars but reduced richness ($p = 0.005$, 286 ± 19.6 vs 193 ± 17.7) in gilts, which did not occur ($p > 0.05$) with Shannon's; however, irrespective of *Malvaceae*, zinc reduced Faith PD ($p = 0.008$, 14.31 ± 0.440 vs 12.63 ± 0.407) in gilts. *Malvaceae* also increased richness ($p < 0.001$, 193 ± 17.7 vs 302.76 ± 19.6) and Shannon's ($p = 0.049$, 7.29 ± 0.627 vs 7.67 ± 0.532) in gilts on zinc, but not Faith-PD ($p > 0.050$). *Malvaceae* inclusion reduced ($p < 0.050$) the distance of gilts from boars on all beta-diversity metrics except weighted-unifrac, where a *Mal-*

vaceae distance was present ($p = 0.029$) regardless of sex. Overall, there were 10 differentially ($p < 0.05$, ANCOM > 0.8) abundant species due to *Malvaceae*. Whereas by sex, 33 species within gilts and 37 within boars were differentially abundant due to *Malvaceae*.

Conclusions
Malvaceae minimised the non-phylogenetic, alpha-diversity loss caused by zinc within gilts, and modified the microbial composition of gilts to be closer to boars. Investigation into the implications of and reasons for these sex dependant effects in conjunction with other health parameters is necessary for further development.

Acknowledgments
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159

Virtual fencing: How does it impact behaviour and welfare in grazing beef cattle?

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Application
This study looked at the concept of virtual fencing and provides some very important and timely information on the efficacy of the technology and whether it is a welfare-friendly means of containing grazing livestock.

Introduction
Virtual fencing is a system which enables livestock to be contained without the use of a physical fence. The technology typically comprises a mobile phone application, through which the user can map out the virtual boundary, and a GPS-enabled neck collar fitted on the animal. When the animal approaches the boundary, it receives an audio warning to turn around. This is followed by an electric pulse in the event that an animal proceeds beyond the virtual fence boundary. These systems have potential to aid farmers in managing grazing livestock in a range of scenarios however the key question surrounding its adoption is whether it has an impact on animal behaviour and welfare.

Materials and methods
To investigate the effect of virtual fencing on behaviour and stress levels, 64 dairy-origin calves were assigned to one of two treatments in a randomised complete block design, with 4 groups of 8 calves per treatment. The two treatments were virtual fencing (VF) and electric fencing (EF). The experimental period lasted 31 days in total, consisting of a 10-day training period and a 21 day grazing period. On days 1 to 10 both treatment groups were trained using a single electric or virtual fence line in their respective paddocks, with barbed wire fencing making up the remaining three sides. From day 11 until day 25 three of the four sides of the grazing area were either electric of virtual fence, and from day 26 to 31 animals were fenced entirely in a four-sided electric or virtual area. Stress and behaviour of the animals was measured using faecal cortisol metabolites, activity pedometers, and behavioural recordings. Virtual fence data denoting the number of audio and electrical stimuli delivered for each animal were also recorded.

Results
Results show that there was no significant difference in animal stress or behaviour between EF and VF cattle in the current study. Additionally, there was no significant difference in daily liveweight gain between treatments. In the VF animals the average rate of electric pulses declined after an initial learning period, with variations in the rate of learning observed between individual animals.

Conclusions
This study has demonstrated that virtual fencing can be an effective alternative to conventional electric fencing, without negatively impacting behaviour or stress levels in beef cattle. The variation in learning between individual animals in virtual fencing systems however warrants further study.

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160

Using precision technology to investigate personality and plasticity of movement in farmed calves and their associations with weight gain

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Application
Behavioural indicators have become popular in a move towards positive welfare and early detection of disease in farm animals. At the same time the study of animal personality has established that most species show strong individual variation in their behaviour. Therefore, the results of our study, which include evidence of personality traits and their effects on behavioural plasticity and weight gain, would inform future research and applications of behavioural measures.

Introduction
Individuals within a population show consistent differences between each other in their average behavioural expression (personality), and in their response to environmental changes (plasticity). In farm animals this variation can impact individual requirements and have effects on disease susceptibility and welfare. The aim of this study is to utilize the recent developments in precision livestock technologies to quantify personality types from movement behaviours, measure consistency of personality and plasticity and use these insights to improve the current methods for the detection of disease and welfare measurements.

Materials and methods
We measured individual variation in movement using sensors that continuously recorded the location of 64 calves for the first 5 months of their life, following their move between 3 different housings. The data were analysed by fitting mixed-effects models for walked distance with the housing as the random slope. This allowed us to calculate the repeatability of the behaviour as the calves were moved and the interaction between personality and plasticity.

Results
The results showed that there are consistent differences in walked distance across housings as the proportion of the total variation due to the individual was 0.20, indicating consistency in behaviour, and therefore personality types, despite the change in context. There was also a positive correlation between intercept and slope of 0.70. This indicates that different calves are affected differently by changes in housing and that personality type is predictive of this difference in plasticity. Finally, there was a positive correlation between the walked distance and weight gained by the calves ($r = 0.26$, $p = 0.04$), indicating a connection between an active personality type and growth rate.

Conclusions
Overall, this study shows that the active personality trait is stable in in young farm housed calves for 5 months, despite the changes in environmental conditions and in group composition. This means that movement levels are inherently different between individuals even at such a young age and these patterns affect the individual response to change as well as their growth rate. This demonstrates the importance of measuring individual variation to understand production outcomes and inform management decisions. Finally, such individual differences need to be accounted for when using behaviour as an indicator for health or welfare.

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161 (Invited Speaker)

Nutritional strategies to mitigate heat stress in pigs; What we have learnt in Australia that can be applied overseas?

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Pigs are comparatively less heat tolerant than other species of production animals, which poses challenges for herd productivity during summer heat waves. The issues surrounding heat and pig production are predicted to increase, based on the actions of climate change increasing the intensity, frequency and duration of heat waves. Furthermore, future growth areas of pig production will be in tropical regions such as South-East Asia, Latin America and Africa. The behavioural and physiological responses in pigs to heat stress include a reduction in activity, decreased feed intake, increased rectal temperature, increased respiration and panting rate and diversion of blood from the internal organs and tissues to the periphery in order to dissipate heat. A further consequence of heat stress is oxidative stress, particularly in the internal organs where blood flow is decreased. These efforts by the pig to dissipate excess body heat come at a cost to health and divert energy away from growth, compromising efficient pig production. Heat stress management requires multiple strategies to address the altered physiological state in heat-stressed pigs.
In Australia, pig sheds often have very little environmental control, so producers must rely on other strategies to ameliorate heat stress in summer. Recent research is improving the understanding of applying nutritional strategies to ameliorate the effects of heat stress. In particular, the use of feed additives is an important, flexible and economical method to alleviate heat stress and the intensive nature of pig production lends itself to the use of additives. Some specific examples include antioxidants, betaine and chromium, which have been proven effective in mitigating certain impacts of heat stress in pigs. Dietary antioxidants such as Vitamins C and E and selenium can reduce heat stress and the gut damage caused by oxidative stress. However, the doses of selenium used may be beyond that allowed in some jurisdictions. Betaine, or trimethyl glycine, is derived commercially from sugar beet and can act as an antioxidant and an osmolyte. This latter action reduces the need for cellular ion pumping to maintain osmolarity and reduces heat production. One of the adaptations to heat stress is increased insulin sensitivity, presumably to reduce fatty acid oxidation and improve blood flow to the skin. Chromium is an insulin mimic that further increases insulin sensitivity and reduces heat stress. More recently, plant-derived phytochemicals and alkaloids are being investigated as alternatives to antioxidants such as selenium, and it is likely that this burgeoning area will provide useful dietary strategies to mitigate heat stress. The aim of this paper is to summarise recent advances in the nutritional management of heat stress in pigs.

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162 (Invited Speaker)

Exposure to bushfires impacts sheep health and beef meat quality

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Application
In the aftermath of exposure to bushfires, a small increase in pneumonia occurs in sheep and a significant increase in unacceptable high ultimate pH in beef loins occurs, which may warrant consideration for withholding cattle from slaughter from an economic perspective, after decisions based on welfare grounds have been made. These observations will inform practical recommendations to improve health and productivity outcomes in management of bushfire-affected livestock.

Introduction
In Australia, the 2019/20 bushfire season involved a particularly severe and widespread fire emergency ('Black-Summer' bushfires). Understanding of how exposure to bushfires affects specific disease processes, and beef quality, in livestock is limited.

Materials and methods
This research investigated spatiotemporal relationships between bushfire exposure and pneumonia/pleurisy in slaughtered sheep, and meat quality in slaughtered cattle. The studies used historical abattoir monitoring data from the National Sheep Health Monitoring Project (n = 1,656,498; Hillman et al., 2022) and Meat Standards Australia Program for beef (n = 451,299; Hastie et al., 2022). The study area was in Australia and comprised areas heavily affected by 'Black-Summer' bushfires. Carcases were matched to fire occurrence data and to rainfall/pasture data for farm origin. The modelling included generalised additive mixed effects models and generalised linear mixed models.

Results
Consistent though imprecise trends in pneumonia occurrence in sheep carcases were observed, with sheep slaughtered in the immediate aftermath of exposure to high intensity fires at a close distance having the highest occurrence (0.378% for sheep slaughtered 5 days after exposure to medium-to-high intensity fire, 0.5 km from fire, compared to 0.0378% for sheep across the study population). No trends were observed in pleurisy occurrence in sheep. Modelling of beef loin ultimate pH at grading showed that increased incidence of high loin pH occurred in grass-fed relative to grain-fed (2-times higher), HGP-treated cattle relative to non-HGP (5-times higher), higher duration of fire burning in non-HGP cattle (not in HGP-treated cattle), and in older animals (higher ossification) ($P < 0.05$ for all). Decreased incidence of high loin pH occurred for cattle at greater distance from fire if grain-fed (not if grass-fed), greater Bos indicus content, and increasing time since the fire ($P < 0.05$ for all).

Conclusions
Exposure to bushfire is associated with increasing pH in the beef loin but the extent and magnitude of these increases are modulated by production factors. Sheep exposed to bushfires had a small increase in pneumonia.

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163 (Invited Speaker)

Drought Resilience Adoption and Innovation Hubs – Building resilience in Australian farming systems

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While there are various types of drought (NCEI, 2022), I define drought as a lack of rainfall, resulting in severe water shortages for typical functions. For livestock producers this impacts pasture growth, livestock productivity, wellbeing and cost of production. For rural communities it can affect water available for drinking, domestic and recreational use.
Drought is one extreme of the spectrum of climate variability experienced by Australian farmers. Drought is often presented as an emotional disruptive force to be absorbed and endured. Alternatively, it can be considered as a business risk for which management can adapt or transform using rational planning skills and scientific knowledge (Burdon, 1995).
The Australian Government established the AU$5 billion Future Drought Fund to provide continuous secure funding for drought resilience initiatives to prepare for the impacts of drought (DAFF, 2022). The Future Drought Fund supports eight Drought Resilience Adoption and Innovation Hubs across Australia, providing farmers with access to locally relevant tools and education to increase drought resilience. The University of New England (UNE) hosts the Armidale Node of the Southern Queensland and Northern New South Wales (USQ, 2022) Hub. Armidale Node activities are underpinned by listening to farmers and communities to understand their needs, and then designing activities to build skills in drought management, as a part of addressing climate variability and business risk. Increasing the use of credible information and forecasting for critical decisions and business planning are fundamental to drought resilience. The UNE Node offers a range of programs and tools. For example, the Farming Family Reboot program is a 2×3-day intensive residential school delivered by UNE staff and Node partners. The program focusses on personal wellbeing, decision making, business skills, goal setting, succession planning, and climate forecasting linked to pasture and livestock skills for feed budgeting.
UNE also provides www.ag360.com.au as a free software platform to livestock producers across Australia. Ag360 provides a 180-day weather forecast, on a daily time step, customised to a 5 km scale. This weather forecast is combined with farm management information and used in soil moisture, pasture and animal growth models to predict future conditions and production and provide early warnings when performance may fall short of targets. The predictive analytics of Ag360 assist livestock producers to be prepared for drought and make timely management decisions to respond to climate variability on a daily basis.

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164 (Invited Speaker)

The physiology of heat stress in beef cattle

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Heat stress is a leading cause of production losses and negative welfare outcomes for animal industries globally. Heat stress is a complex and dynamic interaction between climatic conditions, animal behaviour and physiology. Describing and understanding the impact of hot climatic conditions is not new, given the plethora of research that exists not only about understanding heat stress but also mitigation pathways. However, climate models project an increase in global temperatures, of up to 6 °C, by 2100 and it is evident that the global environment is changing (IPCC, 2021). In addition to increasing global temperatures, models predict an increase in extreme weather events, more frequent heat waves, and longer hotter summers (IPCC, 2021). As such, it is envisaged that animals will be exposed to consecutive and more persistent heat challenges.

The physiological management of heat stress involves the engagement of organs, tissues and body fluid compartments (Wijffels et al., 2021), as such animal responses can be classified into three categories: (i) behavioural; (ii) physiological; and (iii) haematological and in a majority of circumstances all of these responses are occur simultaneously. Initial responses to hot condition typically centre around the avoidance of solar radiation, e.g. shade seeking (Lees et al., 2020). Where behavioural responses fail to prevent heat accumulation, respiration rate and panting increase (Lees et al., 2020), typically coinciding with body temperature increases. From a haematological perspective, numerous adjustments occur however there is significant variability across studies (Wijffels et al., 2022), which may be associated with differences in climatic conditions. Finally, heat shock proteins (HSP) should also be considered due to their protective role, however results are inconsistent as HSP's are not only expressed in response to thermal stressors (Collier et al., 2008).

Defining the most appropriate measures to evaluate heat stress is challenging, under both laboratory and field conditions due to the variability of responses that exists between individuals. Nevertheless, evaluating body temperature will always remain an important mechanism to quantify heat stress. Due to the complexity of responses that exits it is important to have an appreciation of the cumulative effects of the animals' environment, both thermal and phenotypic, however this is where the development of climatic indices becomes paramount (Gaughan et al., 2008; Mader et al., 2010). The purpose of climatic indices is to provide a tool for the strategic management of livestock during adverse climatic conditions. Regardless the impact of hot conditions cannot be completely removed. As such a key focus of heat stress research should remain primarily on developing effective management strategies to support animal comfort and performance during periods of heat stress.

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165 (Invited Speaker)

Comparative heat tolerance in different sheep breeds; Heat waves and their impact on sheep production and meat quality

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Application
Heat stress is a significant challenge for global sheep production compromising animal welfare and productivity over the hot summer months (Chauhan et al., 2021). Chronic exposure of animals to heat reduces production due to the diversion of energy for thermoregulation (Gowane et al., 2017).

Introduction
Susceptibility of individual animals to heat depends on the production levels and high producing animals are more vulnerable to heat stress (Garner et al., 2016). Selection of heat tolerant sheep for breeding could be one of the strategies to improve heat tolerance and minimize the impact on sheep production and welfare (Joy et al., 2020). We compared the thermotolerance of Dorper and 2nd Cross (Poll Dorset × Merino/Border Leicester) lambs by assessing their physiological, biochemical, hormonal, and molecular responses to heat stress and measured the impact on meat quality.

Materials and methods
After acclimatization to indoor housing, 4–5-month-old lambs of each breed were exposed to either thermo-neutral (18 °C–21 °C, 40%–50% RH, n = 12/group) or cyclic heat stress (28 °C–40 °C; 40%–60% RH, n = 12/group) for 2 weeks in climatic chambers. The heat stress involved exposure to temperatures of 38 °C–40 °C between 08.00 and 17.00 h daily and the temperature was maintained at 28 °C overnight. The lambs were provided access to *ad libitum* feed and water. The data were analyzed using the residual maximum likelihood (REML) variance component analysis procedure for GenStat.

Results
Overall, two weeks of heat stress significantly altered growth rate, physiology, blood biochemical profile, prolactin concentration, gene expression patterns and meat quality attributes in both the breeds. However, there was significant interaction between breed and heat stress and water intake ($P < 0.001$), feed intake ($P < 0.05$), respiration rate ($P < 0.001$), rectal temperature ($P < 0.001$), skin temperature ($P < 0.001$), blood urea nitrogen ($P < 0.05$), creatinine ($P < 0.05$), non-esterified fatty acid concentrations ($P < 0.05$), prolactin concentrations ($P < 0.001$), as well as heat shock protein ($P < 0.001$), interleukin 2 ($P < 0.05$), and prolactin receptor ($P < 0.05$). mRNA expressions showed variable response among the two breeds. Compared with second cross lambs, Dorper lambs exhibited a lower respiration rate and rectal temperature and less decline in body weight during heat stress. Conversely, second cross lambs had higher body weight gain than Dorper under thermoneutral conditions. Heat stress increased a* value and chroma of the Longissimus thoracis et lumborum (LTL) of second cross lambs over 10 days retail display but had no impact on Dorper lambs.

Conclusion
Under the controlled conditions, Dorper lambs were comparatively less influenced by heat stress indicating superior thermotolerance as compared to second cross lambs.

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166 (Invited Speaker)

Hammond Lecture: What do farmers and the food industry need from animal science?

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In answering the question, 'What do farmers and the food industry want from animal science?' we must consider what is being asked of farmers and the food industry from consumers and the marketplace, and then identify the solutions and innovations animal science can provide.
During her lecture, Minette will set out the challenges and priorities facing her farmer membership, from changes in the way consumers are spending money on food, to environmental and ethical commitments and economic and trade constraints.
She will challenge you all to think collaboratively about the problems facing the farming sector and the role that animal science can play in finding and implementing solutions.
Be bold and enthusiastic in your thinking, apply your knowledge and see yourselves as part of the solution.
Her challenges to you are:
The need for a responsive animal science sector which understands and responds to the global economic pressures which will be driving farmers' actions in this time of change.
Be scientists who understand farm business needs and market pressures, and who can work in partnership with industry to find solutions to disease, environmental and productivity challenges.
Bring us innovations in diagnostics and preventative animal health care – this includes creating new vaccines and new testing regimes which can be used confidently by farmers and skilled stockmen, and which provide an immediate positive impact to farm productivity.
Create, and work to, a regulatory system which responds quickly to new technologies that you can provide – a pharmaceutical solution is no solution if its introduction and implementation is held up for years as it goes through lengthy, bureaucratic licensing and registration processes.
Help farmers to invest confidently in disease surveillance and data collection, including an effective network of post-mortem surveillance.
Be part of an exciting movement demonstrating that the UK is as an attractive and interesting place for new scientific talent and ideas.
Relate all that you do to the world around you. Adopt a One Health mindset.
As a starter for ten, consider every action you take and how it relates to:

- Methane reduction targets and energy efficiency.
- Enhanced animal health and farm productivity.
- Innovative veterinary science; and
- What can you so to make farm infrastructure and businesses future fit?

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167 (Invited Speaker)

The truth about meat's contribution to human nutrition – beyond protein

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Meat is a nutrient-dense food, providing B vitamins, saturated and unsaturated fatty acids and, depending on the species and cut, useful amounts of vitamin A, vitamin D, selenium, iron, zinc and potassium. Often vilified nowadays for its climate impact and association with risk of colorectal cancer, red meat may still have an important place in the diets of those who choose to remain omnivores in spite of the persistent promotion of plant-based and vegan diets. Firstly, the micronutrients in meat can theoretically have a positive health impact, according to authorised health claims, and may help to address nutrient shortfalls, for example low iron intakes in women and girls. Secondly, if cooked in line with dietetic advice, meat is nutritionally superior to many commonly-eaten plant-based alternatives, particularly because specific nutrients, such as iron and zinc, are more bioavailable. Thirdly, when considering the evidence linking red meat with non-communicable diseases, notably colorectal cancer but also cardiovascular disease and type 2 diabetes, there is an overreliance on observational studies which are subject to methodological disadvantages, such as confounding, bias and superficial dietary assessment, which limit their interpretation in the context of dietary recommendations. This presentation will explore the nutritional value of meat, particularly red meat, and consider how the evidence on health impact may have been skewed by the use of observational studies. While there are only limited randomised controlled trials on red meat and markers of health, the findings of these typically do not fit the 'meat is harmful' narrative provided by epidemiological studies and this deserves further assessment to ensure that dietary recommendations are based

on the entirety of evidence. Most people in Western countries choose to eat meat. Hence, it can be argued that it is better to provide advice on the cuts, cooking styles, amounts and frequencies of meat that provide optimal support for health, rather than promoting avoidance or blanket reduction, which may have the unintended consequence of nutrition gaps for certain sub-populations.

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168 (Invited Speaker)

The contribution of meat to childhood nutrition – Current challenges and opportunities

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Nutritional needs vary across the lifecycle, with childhood a time when optimal nutrition is particularly important to support critical stages of growth and development, and to help prevent disease in later life. Sufficient protein is required for rapid bone and muscle growth and, for brain development, iron, folate and vitamin B12 are particularly important. Yet, several of these important nutrients are low in childhood diets, particularly of iron; the most common micronutrient deficiency among children worldwide and leading cause of preventable impaired cognitive development.
Meat plays a valuable role in a child's diet contributing all essential amino acids, as well as highly bioavailable vitamin A, vitamin B12, iron, zinc and selenium. Ruminant meat is also one of the few dietary sources of long chain n-3 polyunsaturated fatty acids (PUFA), particularly in forage-based feeding systems. The intake of n-3 PUFA is crucial for early brain development, but intakes remain low in Western countries.
There is plausible evidence from observational studies on the association between consumption of meat and improved child growth and neurodevelopment. However, a recent Cochrane review comparing the effects of meat-based diets to plant-based diets (PBD) on child growth and development emphasises the lack of high-quality data from intervention trials. The authors sourced the majority of limited data from developing countries, where several trials report increased height and weight gain among children consuming meat-based compared to PBDs. It is likely that the apparent benefits of consuming meat in childhood are due to a synergistic effect through the combination of high-quality protein, vitamins and minerals provided. In UK children aged 4–10 years, where meat intakes average 67 g per day, meat contributes considerable amounts to daily energy and nutrient requirements.
Food-based dietary guidelines in many countries now advise limiting red and processed meat and increasing the intake of protein from non-meat sources, such as legumes, pulses, cereals and fish. It is important to note that there are no such recommendations on meat consumption for children. Despite the perceived benefits for health and environment, vegan and vegetarian diets are associated with an increased risk of nutrient deficiency, with serious implications for child growth and cognitive development. Although many micronutrient deficiencies can be corrected, the implications for cognitive development may be longer lasting and as such, more comprehensive evidence is required on the effects of meat-free diets for child growth and development in order to inform national public health guidance.
In summary, meat continues to be an unrivalled dietary source of protein and nutrients, which can support healthy child growth and development. In the face of changing dietary patterns, with an increased emphasis on sustainable diets, it is important that public health messages responsibly portray the health benefits of consuming meat for children.

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169 (Invited Speaker)

Benefits of animal-source foods in developing countries

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Livestock play a pivotal role in low-and middle-income countries (LMIC), and in some up to 80% of the population depend on livestock for their incomes. In LMIC, the livestock contribution to agricultural GDP is 40% on average but can be as high as 80%. Livestock keeping is also among the most effective pathways to women's empowerment in LMIC and is one of the proven strategies for increasing the resilience to external shocks of smallholder farmers who provide the bulk of the food supply. In addition, in many rural areas in LMIC, livestock are still the predominant source of farm traction and their manure is the main crop fertilizer and is used for fuel or for building houses. Livestock also play a pivotal role in cultural traditions for instance as dowries, insurance, and they are societal status symbols. However, the role of the animal-source foods (ASF) from livestock in ensuring food and nutrition security is perhaps their most important and least appreciated one. According to a 2021 UN report, 150 million more people were affected by hunger in 2021 than in 2019 and the trifecta of the COVID 19 pandemic, the Ukraine war and natural disasters are worsening the problem by causing exponential increases in prices of food, fertilizer

and fuel, particularly in LMIC. Among children under five, 149 million were stunted implying impaired physical and cognitive development and 45 million were wasted and thus faced a twelve-fold higher mortality risk. By far, most of these cases are in LMIC, particularly South Asia and Sub-Saharan Africa, where severe food and or nutrition insecurity is rife in some rural areas. Animal-source foods can play a pivotal role in preventing and mitigating childhood wasting and stunting because of their unique macro and micronutrients and bioactive compounds. Compared to plant source-foods, ASF have superior quality protein and greater and or more bioavailable forms of iron, zinc, vitamin A, vitamin D3, choline, EPA and DHA, thiamin, riboflavin, vitamin B6, and vitamin E. They also contain the only natural source of vitamin B12. Since most of these nutrients are critical for cognition and growth, particularly in the first 1000 days of life, ASF can greatly reduce stunting and wasting in LMIC. Recent studies support these claims and some suggest that by improving cognition and hence education, they may contribute to economic development in LMIC. Compared to fortificants used for diet augmentation that supply one or two deficient micronutrients, ASF simultaneously supply several micronutrients, and their use can be more sustainable. Unfortunately, levels of ASF consumption in the rural areas of many LMIC remain very low due to low accessibility, affordability and availability. Multisectoral research, extension and policy initiatives that address these problems are critically needed.

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170 (Invited Speaker)

How evidence can win over narrative – Lessons from the UN Food Systems Summit 2021

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There is a misunderstanding among the general public, that the role of science is to provide positive answers about the truth. Truth-seeking is the task of a different faculty in society, namely the various churches and religions, and is better left to them. The role of scientists is to search for evidence, to refine the methods, tools and models with which the world can better comprehended. In order to function well, science must debate each other, and be willing to overturn paradigms of dearly-held positions in favor of better insights. Sciences thrives on asking questions, not on knowing the answer.
General society has little patience with the tedious process of scientific progress where often the answer of scientists to society's questions is "It depends". Decision makers therefore appreciate if there are scientists who come forward with a firm conviction that they have found THE answer. And those scientists in turn are flattered at being listened to. Soon enough, the scientist turns into an activist, and the principles of good scientific conduct are abandoned for the sake of providing the answer which the decision maker wants to hear. It is a rubicon which scientists should not cross, but too many do.
For the UN Food System Summit 2021, a group of highly interested society groups had publicly declared in writing, that they want the Summit to become a milestone of achievement on the path to radically reduce the role of livestock in global society. Towards that purpose, they had been coopting a number of scientific supporters who are persistently short on creating scientific evidence, but are strong on providing anti-livestock answers.
This presentation will be a case study in how another group of scientists used the principles of good scientific conduct and the strength of scientific evidence to prevent the cooptation of the UN Food System Summit from becoming an anti-livestock event, and on the contrary to achieve a livestock-welcoming resolution based on evidence. The presentation also highlights how the same scientific principles continues being employed to separate the nonsense from the evidence.

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171

Level and form of supplementary zinc alters zinc status and performance in dairy cows

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Application
Feeding higher levels of zinc in an organic form can be used by dairy farmers to improve the zinc status of cows and increase their energy balance, although milk fat levels can be lower and hoof hardness may not be affected if fed for only 14 weeks.

Introduction
Zinc (Zn) is a trace element that is present in all classes of enzymes and is an essential component in the diet of dairy cows (Suttle, 2022). Previous studies have reported that higher feeding levels and supplying Zn in an organically chelated form can increase milk production

and may reduce somatic cell count (SCC), but the effects on hoof hardness are less clear (Cope et al., 2009; Suttle, 2022). The objectives of the study were to determine the effect of the dietary concentration of Zn when supplied in an inorganic or organically chelated form on the intake milk performance, Zn status and hoof hardness in dairy cows.

Materials and methods
Sixty Holstein-Friesian dairy cows that were 47 d (SE ± 1.7) post-partum at the start of the study were fed a basal diet that contained 26 mg Zn/kg DM and received one of 4 dietary treatments for 14 weeks: low supplementary Zn (+20 mg Zn/kg DM) in the form of Zn oxide (LO) or Zn- bisglycinate (LP); or high supplementary Zn (+40 mg Zn/kg DM) in the form of Zn- bisglycinate (HP), or as equal amounts of Zn oxide and Zn- bisglycinate (OP). Intake and milk yield was monitored daily, with milk samples collected fortnightly. Hoof hardness was measured at weeks 0 and 14, and blood samples collected during weeks 0, 2, 6, 10 and 14 of the study. Data was analysed by repeated measures ANOVA using Genstat.

Results
There was no effect ($P > 0.05$) of dietary treatment on dry matter intake or milk yield, with mean values of 24.8 and 40.6 kg/d respectively. Milk fat content was 2.9 g/kg higher ($P < 0.05$) in cows receiving LO than HP, with those offered LP or OP being intermediate. There was no effect ($P > 0.05$) of treatment on milk somatic cell count or hoof hardness. There was also no effect ($P < 0.05$) of treatment on blood plasma Zn concentration, but plasma superoxide dismutase concentration was higher ($P < 0.05$) at week 14 in cows fed HP than LO.

Conclusions
Feeding Zn in an organic form at a higher level improved Zn status and reduced milk fat concentration in dairy cows. However, treatment did not affect milk SCC or hoof hardness when fed for 14 weeks.

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172

Increased rate of inclusion of *Yucca shidigera* extract alters the rumen microbiome, fermentation profile and rumen ammonia concentration in dairy cows

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Application
Supplementation of *Yucca shidigera* in dairy cows reduces ruminal ammonia concentration and has beneficial effects on the stability of the rumen microbiome.

Introduction
Yucca shidigera has previously been shown to reduce rumen ammonia in culture systems and *in vivo*, affecting microbial growth and metabolism (Wallace et al., 1994; Hristov et al., 1999). However, few studies have characterised the effect on the rumen microbiome to identify microbial biomarkers associated with *Y. shidigera* supplementation.

Materials and methods
Four multiparous Holstein-Friesian dairy cows were used in a Latin square design with four periods of four weeks duration with all sampling taking place during the final week. The cows were milked at 0600 and 1600 h and fed at 0800 h with a rate of inclusion (ROI) of 0 g, 5 g, 15 g or 30 g/day of *Y. shidigera* added to the total mixed ration. Digesta samples were collected via rumen cannula at 1100, 1400, 1600 h and separated into liquid and solid phases for volatile fatty acid, ammonia and microbiome analysis.
Microbiome analysis was conducted using 16S rRNA gene sequencing based on Kozich et al. (2013). Cow performance and rumen metabolism data were analysed using repeated measures ANOVA. The treatment degrees of freedom were further split into linear, quadratic and cubic effects. Microbial diversity was measured using Bray Curtis dissimilarity with *P* values determined using PERMANOVA. Taxonomic biomarkers were identified with linear discriminant analysis (LDA) effect size (LEfSe) >2.0 within each of the digesta phases.

Results
Maximum rumen ammonia showed a linear decrease to ROI of *Y. shidigera* ($P = 0.044$). VFA were unaffected with the exception of propionate concentration, which showed a linear increase with ROI ($P = 0.010$). The range (maximum – minimum) in rumen pH also decreased with ROI *Y. shidigera* ($P = 0.004$). In the combined LPD and SPD samples, reduced ratios of Firmicutes:Bacteroidetes phyla and Archaea:Bacteria domains were associated with a higher ROI of *Y. shidigera*. Microbiome alpha and beta diversity were not affected by ROI either in the LPD ($P = 0.180$) or SPD ($P = 0.059$) samples. However, in the LPD samples a decrease in abundance of the biomarker *Methanobrevibacter millerae* (LDA = 2.15) and an increase in abundance of an OTU classified to an unclassified genus of Proteobacteria (LDA = 2.10) was correlated with *Y. shidigera* ROI. Cow performance was not affected in terms of DMI or milk yield ($P > 0.05$) with mean values of 23.2 and 36.8 kg/d respectively. However, there was a linear increase in milk fat content ($P < 0.03$).

Conclusions
Increasing the rate of inclusion of *Y. shidigera* reduced rumen ammonia concentrations, resulted in a more stable rumen pH and reduced methanogen abundance without affecting milk yield. The findings can be used to indicate the effects of *Y. shidigera* supplementation during normal use on farm.

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173

Performance and milk quality in organic dairy cows[StQuote] herds

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Application
Increased grazing in organic systems may increase the outputs (milk, fat, protein) per kg of expensive diet ingredients, and improve milk fatty acid (FA) profile.

Introduction
Increased demand for pasture-fed cows' milk, has increased organic milk production. Literature highlights reduced yields, but higher fat and protein (g/kg milk) as production intensity decreases (Stergiadis et al., 2012). Milk from pasture-fed cows has been associated with a more desirable fatty acid (FA) profile (Stergiadis et al., 2015). However, herd-level organic vs conventional simultaneous comparisons on feed efficiency and milk FA profile are scarce. This study investigated the implications of organic management on herds' efficiency and milk quality.

Materials and methods
Bulk-tank milk samples ($n = 801$) were collected monthly, over 12 months, from 67 dairy herds across Southern England, to represent conventional (41 herds) and certified organic (26 herds) along with diet and breeding data via questionnaires. On average, in conventional and organic farms forage:concentrate ratio was 61:39 and 74:26, respectively; while Holstein cows represented 80% and 66% of the herd, respectively. Milk composition and FA profiles were determined using FTIR and GC, respectively. Grazing intake was calculated as estimated DMI from average herd breed live weights and milk yield) minus offered DM (kg conserved and concentrates). Data were analysed by repeated measures, linear mixed models (GenStat 19.1), using system (organic, conventional), month (January-December) and their interactions as fixed factors, and farm ID as random factor. Multivariate redundancy analysis (CANOCO 5) assessed associations of breed and diet with milk and solids yields, feed efficiency and FA profile.

Results
Conventional herds had higher yields (kg/cow/day) of milk (+7.3), fat (+0.27) and protein (+0.25), and better efficiency (yields/kg DMI) (+0.29 kg milk, +10.7 g fat, +9.9 g protein). However, organic herds produced more milk (+1.23 kg), fat (+51 g) and protein (+42 g) per kg concentrate DMI. Organic milk contained (g/kg FA) more saturated FA (+14; mostly short-chain saturated FAs), α-linolenic acid

(+2.37), rumenic acid (+2.06), and eicosapentaenoic acid (+0.22); but less monounsaturated FA (−16 g/kg FA). RDA showed that grazing was positively correlated with milk, fat and protein yields per kg concentrate intake and with nutritionally beneficial FAs.

Conclusions
Whilst conventional herds showed higher feed efficiency (milk and solids yields/kg DMI), organic herds showed superior efficiency when expressed per kg concentrate DMI; illustrating the importance of grazing in organic herds, to maintain higher outputs per kg of concentrate. Differences between organic and conventional FA concentrations in milk, mainly due to contrasting feeding practices, were too small to affect consumers' nutrition and health.

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174

Detection of genetic variability in dairy cattle infectivity for bovine tuberculosis

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Application
Genetic selection of cattle with low infectivity, in addition to increased disease resistance, could contribute to controlling and eradicating bovine tuberculosis.

Introduction
Bovine Tuberculosis is a persistent cattle disease in the UK, with significant economic consequences. Earlier studies demonstrated that selection for bovine tuberculosis resistance can be a complementary control measure, and dairy farmers can now select sires for improved resistance in their daughters (Banos et al., 2017). Decreasing cattle infectivity can further accelerate bovine tuberculosis eradication (Tsairidou et al., 2018). The main objective of this study is to determine whether there is detectable genetic variation in cattle bovine tuberculosis infectivity to underpin selective breeding programmes.

Materials and methods
National surveillance bovine tuberculosis data on 2,408,448 dairy cows from 43,000 official breakdowns collected between years 2000 and 2022 were used. Pedigree data were extracted for these cows spanning five generations and amounted to 88,001 records.
This study focused on estimating genetic variation in the infectivity of the index cases. Index cases were defined as the first positive tested cows within 30 days of the breakdown start date. Breakdowns with only one index case were used, and infectivity was then defined as the number of secondary cases per index case (breakdown) identified within the next testing period.
Generalized linear mixed models with either Poisson or Negative Binomial distributions were fitted to the number of secondary cases associated with each index case. The models included fixed effects of herd size, breakdown year, season, county, breed of the index case, and the random genetic effect of the sire of the index case. Models were validated by inspecting residuals and goodness of fit statistics. Permutation test (Pérez-Cabal et al., 2009) was also performed using 200 permutations obtained by randomly shuffling the sire of the index case by keeping other aspect of data structure constant to verify estimated variance component is significantly different than zero.

Results
Heritability estimates of infectivity from the Poisson and Negative Binomial models were 0.46(±0.03) and 0.07(±0.03) in the underlying scale, respectively. Based on the permutation test, both heritability estimates are significantly above zero. The heritability estimates from Poisson model were likely overestimated due to an excess of zeros in the response variable. However, the Negative Binomial model provided a better fit for the disproportionally large number of zero secondary cases.

Conclusions
The study provides empirical evidence that UK dairy cattle vary genetically in bovine tuberculosis infectivity, suggesting that genetic selection for reduced cattle infectivity may be possible in principle.

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175

Effect of lactation stage on the ex vivo cytokine response of whole blood from lactating dairy cows

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Application
Measurement of *ex vivo* inflammatory response by animal blood cells as an alternative to *in vivo* studies. Identify whether whole blood response to an inflammatory challenge differs between early and mid-lactation (EL and ML) cows, so that research can focus on improving the health of EL cows.

Introduction
Immediately after calving, dairy cows are more susceptible to disease, which causes significant economic losses to the dairy industry and negatively impacts on cow welfare (Ingvartsen and Moyes, 2013). This is due to numerous factors, resulting in a low-grade chronic inflammatory state that could be related to production of proinflammatory cytokines (such as tumor necrosis factor-α, TNF-α) by M1 macrophages (Bradford and Swartz, 2020). Therefore, this pilot study tested the hypothesis that production of proinflammatory (TNF-α and interleukin-1β, IL-1β) and anti-inflammatory (IL-10) cytokines from whole blood will differ between EL and ML cows, as well as testing the feasibility of the technique.

Materials and methods
Blood was sampled from 8 multiparous Holstein-Friesian cows at the University's Centre for Dairy Research (n = 4 for EL and ML, mean 1.5 and 108.3 days in milk, respectively) for the measurement of *ex-vivo* cytokine production using whole blood culture (WBC). Concentrations of TNF-α, IL-1β and IL-10 were measured in WBC supernatant samples after stimulation for 0, 2, 4, 6, 8 and 24 h with 0.05 μg/ml lipopolysaccharide (from *E. coli*), by enzyme-linked immunosorbent assays. Statistical analysis (Mixed model, SAS v9.4) included effect of lactation stage, time after stimulation and their interaction as fixed effects, cow as a random effect, and effects were considered significant at $P < 0.05$.

Results
Overall production of IL-1β and IL-10 increased ($P < 0.05$) up to 24 h (tendency to increase with TNF-α; $P = 0.066$). EL cows did not respond differently in terms of WBC *ex-vivo* cytokine production compared with ML cows ($P = 0.999$, 0.824 and 0.254 for TNF-α, IL-1β and IL-10, respectively).

Conclusions
Production of TNF-α, IL-1β and IL-10 by *ex-vivo*-stimulated WBC was found to be similar in EL and ML cows, which may reflect the small number of cows in this pilot study. The increased production of cytokines over time demonstrates that this *ex vivo* method is appropriate for the measurement of inflammatory response by animal blood cells, and could be used as a suitable alternative to *in vivo* studies.

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176

Evaluating differences in the metabolic profiles of lame and non-lame dairy cows using liquid chromatography-mass spectrometry and machine learning

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Application
Decision-making processes regarding treatment against culling and the implementation of management strategies to prevent lameness, by providing an unbiased tool for forecasting this condition using metabolomics to complement visual inspection.

Introduction
In Great Britain, the most recent estimated prevalence of lame cows reported by Randall et al. (2019) was 30.1%, and 31.6% by Griffiths et al. (2018). Previous research indicated that lameness leads to alterations in serum concentrations of metabolites in cows before the presence of clinical symptoms (Zhang et al., 2015). Preliminary data showed that urinary metabolic profiling has the potential to distinguish lame from non-lame cows (Eckel et al., 2020 and Randall (unpublished). In this study, we aim to evaluate differences in the metabolic profile of lame and non-lame dairy cows using liquid chromatography-mass spectrometry (LC-MS).

Materials and methods
424 cow urine samples (214 lame; 210 control) were collected from 10 commercial dairy farms with cows scored using 0–3 mobility scoring ('Mobility scoring for dairy cows | AHDB' n.d.). LC-MS of the samples was performed in 4 different batches. Pre-processing of the generated LC-MS datasets including metabolite identification was performed. Multivariate analysis was performed on all the detected peaks in the urine samples in the study. Principal component analysis was used to check the performance of the analytical run and the batch-to-batch correction using the Systematic Error Removal using Random Forest approach for untargeted metabolomics; while orthogonal partial least squares - discriminant analysis (OPLS-DA) was used to investigate metabolic differences between the classes. Machine learning models were applied to the LC-MS datasets. In addition, previously identified metabolites related to lameness were screened and compared between the lame and non-lame cows across all farms.

Results
Adequate performance of the LC-MS and the batch-to-batch correction approach was achieved. In comparative class analysis at farm level, apparent separation and clustering were observed in 3 farms using OPLS-DA. The screening of the known lame-predictive metabolites from the previous study identified 10 metabolites in this study, of which 2 were predictive of lameness and therefore externally validated. Multivariate Adaptive Regression Spline had the best performance when all farms were included, achieving a prediction accuracy of 69%. At farm level, combining the top 3 farms, overall prediction accuracy was 74%. However, a comparison of the top 10 metabolites identified by the best performing machine learning model on each farm showed that these individual metabolites were not the same across different farms.

Conclusions
A small number of metabolites were externally validated demonstrating the potential to identify metabolites that are predictive of lameness and generalisable across herds. In future research, the reasons for these metabolic differences need to be investigated.

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177

Effect of dietary digestible undegradable protein and amino acid concentration on the growth and development of post-pubertal dairy heifers

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Application
Increasing the digestible undegradable protein (DUP) and amino acid (AA) concentration of post-pubertal dairy heifer diets by 12% provides an opportunity to increase the growth, stature, and feed efficiency of post-pubertal dairy heifers.

Introduction
Dairy heifers account for approx. 15 to 20% of the total dairy farm financial and carbon footprint costs, which are increased by greater replacement rates and age at first calving (AFC) due to lower growth rates. Greater weight gain can be achieved by offering diets of higher crude protein and amino acids (AA) concentrations. Increased crude protein levels given to beef heifers were shown to stimulate the availability of AA in plasma, with heifers fed the higher level of CP also having a higher dry matter intake and average daily gain. However, little research has focused on post-pubertal dairy heifers. This study aimed to assess the effect of increasing dietary digestible undegradable protein (DUP) and AA concentrations on the growth and development of post-pubertal dairy heifers.

Materials and methods
This study was completed at the University of Nottingham (UoN), Centre of Dairy Science and Innovation (CDSI), Leicestershire, UK, between November 2020 and July 2021, using 76 pubertal heifers selected at random (12.4 mo. of age; 399 ± 1.72 kg live weight (LW)) and allocated according to birth date, live weight and breeding value to one of two treatment diets containing industry standard (3.1% $n = 38$) (Lower) and higher DUP (15.1 % $n = 38$) (Higher) concentrations within isoenergetic (13.0 MJ/kg DM) and iso-effective rumen degradable protein (10.9 %) diets, formulated to achieve 1.0 kg/d LW gain (NRC, 2001). Data was of normal distribution and analysed using General Linear Mixed Modelling ANOVA, applying diet as a fixed and individual animal as a random effect, with a confidence interval of 95 % and reporting significant differences at $P < 0.05$.

Results
Higher DUP concentrations increased the LW, hip height, and FE of heifers compared with lower DUP concentrations, while feed intake, body condition, and AFC did not differ.

Conclusions
Increasing DUP from 3.1 to 15.1% increased post-pubertal dairy heifers' growth, stature, and feed efficiency but had no effect on feed intake, body condition, and AFC.

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178

Understanding the production of beef from dairy systems in the UK: An analysis of trends

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Application
This paper draws on comprehensive data of the UK cattle sector to analyse how dairy beef cross (DBX) production changed over time, providing insights into risks and opportunities for future development of the cattle industry.

Introduction
Cattle production systems have evolved into two subsections - beef and dairy - with clear genetic and phenotypic differences (Simm et al., 1996). Recent advancements in reproductive science have enhanced dairy beef cross (DBX) production. We systematically analyse trends in DBX production to identify challenges and associated opportunities for economic viability and performance.

Materials and methods
We utilised data from the Cattle Tracing System (CTS) from 2010 to 2020. Breeding information (breed of the animals and their progenitors), location information, sex and birth and death dates were used to identify trends in production. Mixed effect models and multiple linear regression statistical models, were fitted to analyse differences between breeds, production systems, locations and sex of DBX production. However, there are limitations to these data, for example missing sire information (it is not required by regulation) had to be predicted using the offspring breed information.

Results
The number of DBX animals in the herd grew significantly between 2010 and 2020 (34% and 47% of calves born from dairy were DBX, respectively, in those years). DBX production comes from all dam breeds with two main beef breeds gaining increasing importance recently: in 2010, the Limousin ranked first, followed by Aberdeen Angus and British Blue. While, annual Limousin DBX numbers dropped by 36k, Aberdeen Angus and British Blue grew by 133k and 128k, respectively. Focusing on DBX from black and white dams we found that the British Blue DBX were slaughtered at the same age as pure British Blue (29 months average). Aberdeen Angus DBX were slaughtered on average at 30 months compared to 31 months for the pure Aberdeen Angus. Contrastingly, Limousin DBX had an increased average age of slaughter of 31 months compared to the 28 months of pure Limousin. DBX animals are not only used for meat production, but for in breeding too, though over the 2010–2020 period we found a slight reduction of 3% of DBX cows that had offspring.

Conclusions
The growth of the DBX sector is reliant on two key breeds. The large frame of the British Blue may benefit meat quantity (Mota et al., 2017), whereas the popularity of Angus may be due to its premium price (McHugh et al., 2010). Reliance on two key beef breeds brings a concern about diversity within the system. In terms of opportunities, just as for pure beef animals, a reduction in slaughter age could improve environmental efficiency of the system. Future research – qualitative mapping of DBX breeding decisions –is being conducted to understand how DBX breeding choices are aligned in the supply chain.

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179

Assessing the activity levels of dairy cattle pre- and post-calving

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Application
Identifying changes in the activity levels of cattle over a period of four weeks pre/post-calving to determine whether calving may be predicted and as a potential indicator of stress when calves are removed.

Introduction
Automated technologies offer the opportunity to assess health and welfare by enabling consistent monitoring of cattle. Simple measurements such as cow lying time may be used to assess multiple factors affecting welfare (Tucker et al., 2020). Automated technologies such as pedometers can also improve a farm's ability to predict events such as oestrus thus increasing reproductive efficiency (Yildiz, 2022). The aim of this study was to identify trends in activity levels of dairy cattle pre- and post-calving using pedometers.

Materials and methods
Data for 86 cows was obtained from a dairy farm where cattle were fitted with pedometers. The average number of steps/hour was recorded for each cow for 28 days prior to calving (D-28 to D-1), on the day of calving (day zero) and for 28 days post-calving (D+1 to D+28). Calves were removed at 24 hours old. Data was analysed for trends collectively and in pre/post-calving blocks. Data was also analysed according to whether they were maiden heifers (n = 14) or experienced cows (n = 72). Kruskal-Wallis tests were used to determine if there the average steps/hour were affected by the variables of day or experience.

Results
There was a significant association between the day and the average number of steps per cow when analysed collectively (DF 56, H 268.04, $P < 0.001$) and when data was grouped into maiden heifers (DF 56, H 83.56, $P < 0.05$) and experienced cows (DF 56, H 221.01, $P < 0.001$). Data indicated activity started increasing on day -1 (Mean = 164.6 steps/hour), peaked on day +1 (Mean = 244.8 steps/hour) and did not return to normal until day +12. There was a significant difference between maiden and experienced groups (DF1, H 85.42, $P < 0.001$) with data indicating the biggest difference occurred at the peak period and the activity of maiden heifers remained higher for the post-calving period.

Conclusions
A rise in activity levels at day -1 could be used to indicate parturition, enabling farms to identify cattle likely to give birth within 24 hours. Peak activity levels reached on day +1 when the calves were removed may be an indication of increased stress which took twelve days to return to normal potentially indicating welfare and/or production concerns. Differences between maiden heifer and experienced cattle would suggest this effect is more pronounced in inexperienced animals.

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180

Temporal variation in iodine concentrations in cow and goat retail milk types

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Application
Temporal variation in retail milk iodine concentrations may affect consumers' iodine intake. Agricultural practices to increase iodine content in milk during the grazing season can be recommended.

Introduction
Iodine deficiency is globally the greatest single cause for poor school/work performance and reduced intellectual ability in children and adults and affects embryonic and foetal development in pregnant women (WHO, 2007). In the UK, milk and dairy products contribute 50–64% of iodine intake in children, and 32–41% in adolescents and adults (NDNS, 2020). Although milk iodine concentrations fluctuate substantially throughout the year in farm-level studies, there is limited information about temporal variation in retail milk. The aim of this study was to investigate the seasonal variation of iodine concentration in different retail milk types (conventional, organic, Jersey & Guernsey, goat).

Materials and methods
Milk samples (n = 509) from retail outlets were collected monthly, over 12 months (January–December 2019). This included 42 brands (23 conventional milk, 12 organic, 4 Jersey & Guernsey, 3 goat milk). Iodine concentrations were quantified using inductively coupled plasma mass spectrometry. Data were analysed using linear mixed effects models with milk type, month, and their interaction as fixed factors, and milk ID (nested within milk type) as a random factor.

Results
Goat milk had the highest iodine concentrations (576 μg/kg), Jersey & Guernsey milk had the lowest (217 μg/kg), and conventional and organic milk showed intermediate values (326 and 317 μg/kg, respectively) ($P < 0.001$). Milk iodine fluctuated 131–546 μg/kg throughout the year, with lowest average concentrations been observed during the expected peak-grazing seasons (222 μg/kg), intermediate concentrations during later grazing season (357 μg/kg) and highest concentrations during winter/indoor months (429 μg/kg) ($P < 0.001$). The milk type × month interaction ($P < 0.001$) showed higher I concentration in goat milk, compared to the other types, in February, April, June, and August–November.

Conclusions
There was strong variation in milk iodine concentrations, both due to season (415 μg/kg) and milk type (359 μg/kg); with iodine concentrations being lower during grazing season and higher in goat milk. Given that milk and dairy products are the main source of iodine in UK diets, these differences would impact the contribution of milk to nutritional intakes of iodine. Agricultural practices to increase milk iodine concentrations may be recommended during the grazing period and in Jersey & Guernsey production systems.

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181

Individual cow characteristics influence adaptation to an automatic milking system in dairy cows

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Application
Understanding the drivers of variable milking frequencies within automatic milking systems has the potential to improve welfare, efficacy, and productivity within these systems.

Introduction
Cows that have adapted well to an automatic milking system will voluntarily visit the milking robot at appropriate intervals and at sufficient frequencies to maintain production. However, there currently exists considerable individual variation in the number of voluntary milking visits in commercial settings; with 6–45% of cows requiring 'fetching' to the robot by farm staff (Jacobs and Siegford, 2012), mean-

ing that some cows do not adapt well to these systems. This study investigated the effects of individual cow characteristics, specifically dominance position, social network position, and personality traits, on the cows' adaptation to the robot system.

Materials and methods
Data were obtained from a 48-cow herd newly transferred to an automatic milking system. Agonistic and affiliative interactions collected over a three-week period were used to quantify a dominance hierarchy and a social network of the herd. Using a range of validated temperament tests (novel object, human approach, social runway), all cows were assayed to determine their personality traits. Principal Componant Analysis (PCA) revealed four distinct traits: Activity/exploration, Boldness, Sociality/curiosity, and Locomotor playfulness.
Five separate general linear mixed models were run with the following dependent variables used to assess adaptation; (1) Average voluntary visit frequency weeks 0–2, (2) Average voluntary visit frequency weeks 0–4, (3) Days until the cows' first voluntary milking, (4) Days until the last time the cow had to be fetched to the robot, (5) Challenge of fetching to the robot. All models included cow(subject) as a random effect.

Results
Cows with higher social dominance had a higher average visit rate in weeks 0–4, and a lower latency to their first independent milking. Cows scoring high on the ''locomotor playfulness" trait had fewer average visits in weeks 0-4 and had a longer latency to be fetched for the last time. Cows with high scores on the ''sociality/curiosity" trait also had fewer average visits in weeks 0–4 and were more challenging to encourage into the robot during fetching. There was no effect of personality or dominance on voluntary visit frequency weeks 0–2. Furthermore, cows with previous robot experience adapted better to the system across all tested variables.

Conclusions
Our results demonstrate that dominance and personality traits play a role in adaptation to automatic milking systems and suggest that designing training strategies that target low ranking, playful, and social/curious cows may improve training efficiency, productivity, and welfare.

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182

Indigenous system of dairy cattle husbandry and intensification; impacts on human and animal welfare in Nigeria

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Application
This study will showcase the traditional method of dairy cattle husbandry in Nigeria and how it is limiting intensification efforts by government and individuals for sustainable production and food security and the manifesting effects on the general well being of the animals and peaceful co existence of the cattle herders and the host communities in Nigeria.

Introduction
Cattle milk is one of the readily available animal protein sources for human being as it provides undisputably good profile of amino acids and minerals that are very useful for human growth and development. The affordability as well makes it to be a product of blessing to humanity and any move to increase and or improve its continuous availability is highly welcomed and being supported by nations across the globe and more recently in developing countries and specifically in Nigeria. However, as much as the government in collaboration with international agencies are putting efforts in place, emerging issues emanating from the traditional herders who are mostly pastoralists and the host communities across the nation are not giving the projection safe landing hence this review work which aimed at reporting the conventional system of dairy cattle husbandry, expansion of the dairy sector and consequential effects on the animal welfare and peaceful co-existence among the cattle rearers and the communities.

Materials and methods
The traditional method of rearing dairy cattle was reviewed and matched with the intention of the government, international agencies, business conglomerates to intensify dairy cattle production in Nigeria as one of the sustainable development goals for food security, zero hunger, poverty eradication, infant mortality reduction, safer environment and zero conflict among the communities. Areas in which the general well being of the dairy cattle were compromised were looked into with ways to alleviate these highlighted.

Results
It was clearly discovered that 90.00% of the dairy cattle population in Nigeria is owned by the pastoralists that adopt extensive system of production under which dairy cattle are kept on free range with little or no supplementary feeding and healthcare delivery. Milk yield is usually low as the stock used to migrate over long distances in search of lush pasture especially during dry season. There were cases of clah between the cattle herders and local farmers within the communities over destroy of farm crops by the grazing cattle several of which led to conflicts and loss of human life. However, cattle are free to exhibit their natural behaviors and mate freely. Maenwhile, establishment of dairy farms necessitated intensification in which animals will not be on free range but rather in an enclosure with maximum care in terms of feeding and health management. Productivity is usually and relatively higher however, animals under confinement can not move freely and this is a serious welfare issue. This system requires vast expanse of land and promotes peaceful co-existence of cattle herders and nearby crop farmers.

Conclusions
In order to strike a good balance for the trinity, large expanse of land must be secured for cattle herders and dairy farmers within which they will be rearing their animals without destroying crop farms. Animals must be allowed to go out to graze within the established pasture areas to improve their welfare. Intensification will then be a welcomed system of increasing milk production without compromising the welfare of the animals and will eliminate conflicts too.

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183

Determining optimal time to harvest yellow mealworms following treatment with pyriproxyfen, a juvenile hormone analogue, to maximise protein yield and reduce fat yield

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Application
In *Tenebrio molitor* (TM, yellow mealworms) treated with juvenile hormone analogue, pyriproxyfen, reduction in fat precedes the increase in protein content, suggesting exposure time to pyriproxyfen may be critical to obtain the desired body composition.

Introduction
Although commercially produced insects are a potential source of high-quality protein, their larval stages have a relatively high (25–58%) fat content (Hawkey et al., 2021). Pyriproxyfen increases protein and decreases fat composition as proportion of body weight of TM larvae (Hill et al., 2022). This study determined the time course for changes in protein and fat composition of TM treated with pyriproxyfen.

Materials and methods
After three days acclimatisation on wheat bran (WB), TM (Monkfield Nutrition Ltd) were transferred into plastic dishes (n = 300 TM/dish) and fed one of 3 dietary treatment groups (n = 4 dishes/treatment). All diets consisted of 10 g WB/dish with inclusion of 3 ml acetone vehicle control (Vcont) or 2 mg pyriproxyfen/kg WB (Ldose) or 15 mg pyriproxyfen/kg WB (Hdose). Larvae were kept at 25 °C in a dark incubator at 60% humidity, and fed *ad libitum* feed and water. Dead and pupated larvae were removed throughout. Feed and water were replaced throughout and 30 TM samples were collected at days 0, 4, 7, 14, 21 and 35 and culled using liquid nitrogen and stored at −80 °C. Dry matter crude protein or fat was determined using a FlashEA 1112 Nitrogen Elemental Analyser or Soxhlet ether extraction, respectively. Data was analysed using one-way ANOVA (Genstat 20th edition), followed by post-hoc Bonferroni tests, significance was $P < 0.05$.

Results
There was no effect of treatment on death during or at the end of the trial. Pupation was significantly higher in Vcont from day 21 until the end of the trial ($P < 0.001$). Relative to Vcont, both Ldose and Hdose increased group weight by day 35 ($P < 0.001$), but, when calculated on an individual basis, weight was only greater in the Ldose compared to Vcont ($P < 0.05$). On an individual basis, there was an increase in crude protein by day 14 in TM from Hdose relative to the Vcont, whilst for Ldose this only occurred at day 35 ($P < 0.001$), but fat content was reduced in both Ldose and Hdose by day 14 ($P < 0.001$). On a group basis, relative to Vcont, Ldose and Hdose were not higher for protein until day 35 ($P < 0.001$), whilst reduction in fat content for Ldose and Hdose was reached at day 14, but only Hdose maintained until day 35 ($P < 0.001$).

Conclusions
The effect of juvenile hormone analogue, pyriproxyfen on reducing fat content of TM precedes the increase in protein content.

Acknowledgments
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184

Demonstrating the principles of genetic inheritance in honeybees using SIMplyBee

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Application
Recently, there has been a increased interest in genetic improvement and establishing honeybee breeding programmes. Simulators are a valuable tool in designing and optimising breeding programmes and predicting the outcomes. Existing simulators do not provide all the functionality to simulate a honeybee population due to many specificities. We have therefore developed an R package, SIMplyBee, which extends the AlphaSimR simulator with functionality to replicate haplo-diploidy, polyandry, complementary sex determination, caste system, and colony quantitative genetics. SIMplyBee represents the first holistic simulator for simulating honeybee population management programmes, by enabling flexible simulation of honeybee genomes, biology, reproduction, colony events, and quantitative values at individual and colony levels.

Introduction
Managing genetic variability is crucial for preventing the loss of diversity within local and global populations. Due to recent decreases in honeybee genetic variability, monitoring and managing populations' diversity is therefore crucial not only in conservation programmes, but also in breeding programmes to ensure long-term genetic gain.
In this work we demonstrate the principles of honeybee genetic inheritance and show the genetic relatedness amongst individual honeybees within and between colonies using stochastic simulations with SIMplyBee.

Materials and methods
We simulated founder haplotypes, 800 Apis mellifera carnica (Car) and 1600 Apis mellifera mellifera (Mel), from which we created a base population that underwent a 10-year cycle.
We kept the Car and the Mel populations pure by keeping them in closed mating systems. We also created a hybrid population (MelCross) by mating Car queens with drones from the Mel colonies. Each yearly cycle was broken up into three periods, representing the three seasons. Within these seasons, colonies underwent a series of events, such as colony swarming, supersedure, splitting, and collapse. We recorded the genomic relationships of the whole genome and the complementary sex determination (csd) locus in all colonies at the beginning of year 1 and at the end of the cycle in year 10. From this we computed relatedness between caste members within a single colony, between queens of a same population, and between queens of different populations.

Results
Analysis of relationship correlations in the Car population suggest an increase in relatedness between fathers. Similarly, these correlations are seen between same-population queens. The hybrid population (MelCross) show a decrease in shared alleles, depicting an increase in genetic variability within the population. In comparison, both pure populations show an increase in shared alleles, showing the negative effects of closed populations on allelic diversity. Using Wright's coefficient of inbreeding we showed an increase of inbreeding in queens in pure populations.

Conclusions
Through this simulation we showed the negative impacts of closed mating systems on genetic variability and highlighted the need for programmes to address genetic diversity in honeybees.

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185

Determination of minimal nutrient requirements for *Tenebrio molitor* growth and body composition

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Application
Growth, pupation and death of TM appear to depend more on dietary protein than carbohydrate.

Introduction
Insects are an alternative to common protein sources used in livestock feed (Gasco et al., 2019). insects have a good feed conversion ratio, lower environmental impact and require less land (Liu et al., 2020). This study evaluated the minimal nutrient requirements for (TM) growth, and effects on their % protein and lipid contents.

Materials and methods
A 24-day feeding trial determined the minimal nutrient requirements and effects on growth, pupation and death rates. TM were divided into six diet groups (n = 250/dish, 4 dishes/diet): (A) 100% Wheat bran (WB), (B) 100% Cellulose, (C) 100% Cellulose plus micronutrient premix (premix), (D) 85% Cellulose, 15% Casein plus premix, (E) 85% Cellulose, 15% Glucose plus premix, and (F) 70% Cellulose, 15% Casein, 15% Glucose plus premix. TM were housed at 27 °C and 60% humidity. Food replenished every 10 days. Weights were determined every 3 to 4 days, dead or pupated TM counted. At d24, % protein and lipid contents of dried TM were determined by Nitrogen Elemental Analyser and Soxhlet ether extraction, respectively. Data were analysed by 2- (time × diet) or 1-way (diet only) ANOVA (Genstat 20th edition), with $p < 0.05$ considered significant.

Results
TM fed WB (A) grew the most, followed by the 2 Casein diets (D and F). TM on the other 3 diets (B, C and E) grew more slowly, with the biggest differences observed on days 18, 21 and 24 ($P < 0.001$, time × diet interaction). Significant time × diet interactions ($P < 0.001$) were observed for the numbers of pupated and dead TM, with pupation being higher in WB and 15% Casein diets (D and F), with no pupation in other groups. The lowest death rates were in groups lacking protein (B, C and E), followed by WB (A) and 15% Casein (D), with the highest death rate in group F (Casein, glucose and premix). The % protein content was significantly different ($P < 0.001$), being highest in 15% casein group (D – 71%). There was little difference between groups B, C and F (64–66%), WB was lower (group A – 51%), group provided 15% glucose (group E – 43%) lowest. The % lipid contents were also significantly different ($P < 0.001$), being highest in WB group (A – 27%), followed by group fed 15% glucose (E – 14%), with the rest being much lower (5–9%). We are yet to identify what makes up the remaining % compositions.

Conclusions
The highest growth rate was in WB feed group, followed by 15% Casein, with little growth observed for diets lacking protein. A lack of protein resulted in reduced pupation and death.

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186

Viable and economical insect larvae meal production

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Application
Insect larvae meal could be an alternative to conventional protein sources for animal feed, contributing to sustainability.

Introduction
Insect larvae meal (ILM) is known to contain good levels of protein offering a potential alternative to soybean meal. Before we can commercialise the production of ILM as a source of protein, we have to establish economically and environmentally optimal ways of growing them. The study aimed to examine differing waste stream substrates on the growth rate of larvae as a gut health enhancer for poultry.

Materials and methods
An experiment was approved by the Nottingham Trent University's (NTU) Ethical Review Committee and conducted at the NTU Poultry Research Unit where black soldier fly larvae were fed on 3 waste stream substrates (sourced from Green Eco Technologies, Manchester, UK); food waste (DM: 86%, Protein: 17.6%, Ash: 5%, Fat: 6.8%), sausage waste (DM: 90%, Protein: 22%, Ash: 4.6%, Fat: 17.8%) and sea waste (DM: 85%, Protein: 14.6%, Ash: 15.2%, Fat: 11.6%) with 8 replicate boxes per treatment (18 g larvae in each box). Data on larvae biomass produced, and substrate consumption was recorded and used to calculate gain to substrate ratio. Dry matter content along with protein content were also determined. Data were analysed by one-way ANOVA to determine the effect of waste stream substrate on the response variables. Means were compared using a protected LSD test at $P \leq 0.05$.

Results
Sea waste substrate increased ($P < 0.05$) mealworm biomass gain:substrate (g/g) and crude protein (%) content compared to food and sausage waste streams. However, the dry matter (%) was increased ($P < 0.05$) on food waste.

Conclusions
Sea waste appears to be a better waste stream substrate to raise the larvae meal. However, further investigations are needed to analyse the amino acid profile in the biomass of larvae meal.

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187

Performance of weaner rabbits fed Bermuda grass and Milk weed hay mixtures with concentrate

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Application
Grass-legume mixtures improved low Crude protein contents in Bermuda grass fed to rabbits and prevented incidences of bloat.
Bermuda grass and Milk weed are drought tolerant plants which remained fresh and green during periods when other pastures are scarce or unavailable.
Hence, mixtures of Bermuda grass and Milk weed fed to rabbits ensured availability of good quality pasture for the rabbits during dry season scarce period for optimum productivity at a cheap cost.

Introduction
Rabbit production helps to meet animal protein requirement of Nigerian populace. Scarcity of forages during dry season period causes failure in maintenance or production requirements of indigenous young animals (Alemayehu, 1997). Bermuda grass (*Cynodon dactylon*) and Milk weed (*Euphorbia hirta*) are drought tolerant plants which remain green during dry season and helps to provide fresh forages during scarcity period. Digestibility of feed in animals increase as legumes increased in grass-legume diet. Hence, this study investigates the performance of weaner rabbits fed *C. dactylon* and *E. hirta* hay mixtures with concentrate in Bauchi State, Nigeria.

Materials and methods
Twenty weaner rabbits were allocated to four dietary treatment of *C. dactylon* and *E. hirta* hay at different mixtures (100gCD, 750gCD:250gEH, 500gCD:500gEH and 250gCD:750gEH) in a Completely Randomized Design for 60 days. The rabbits were individually housed in a well- ventilated, cleaned and disinfected cages and routine management practices were done for the rabbits. Concentrate diet was offered at 30 g per animal while forage mixtures (basal diet) were fed at 20 g/kg body weight of animals. Rabbits were weighed and kept in separate metabolism crates for collection of urine and faecal samples (Osuji et al., 1993). Data collected were analysed using One-

way ANOVA procedure (SAS) and DMRT0.05 was used to separate significant means. Experimental model is Xij = μ + Bi + eij where; Xij = Dependent variables, μ = Overall mean, Bi = Treatment diets effect, eij = Random error.

Results
There were significant difference ($P < 0.05$) in Total Weight Gain (0.31–0.40 kg) and Feed Conversion Ratio (69.0–95.5 g/kg). TLWG increased as legume inclusion increased in the basal diet of weaner rabbits and value obtained was higher in 750gCD:250gEH compared to other treatment. Nutrients digestibility except crude fibre were not significantly different ($P > 0.05$) and was higher in 750gCD:250gEH. Crude fibre digestibility ranged from 97.5 g in 750gCD:250gEH to 124.3 g in 500gCD:500gEH and were significantly ($P < 0.05$) different across treatments. Conversely, nitrogen balance, nitrogen absorbed and nitrogen retained were higher ($P < 0.05$) in rabbits fed 500gCD:500gEH (9.61 g/d, 12.6 g/d and 678.2 g, respectively) and could be attributed to lesser nitrogen loss in relation to nitrogen intake in the rabbits.

Conclusions
This study concluded that rabbits can be fed *Cynodon dactylon* and *Euphorbia hirta* hay mixtures up to 500gCD:500gEH without adverse effect. However, 750gCD:250gEH diet mixture gave the best performance in rabbits.

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188

Effect of nano-encapsulated ginger on the physiological response, oxidative status and hormonal profile of rabbits reared in the tropics

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Application
The nano-encapsulation technology of phytogenic bio-components is a new technology employed to solve the unstability challenge associated with phytonutrients, when used as a phytogenic component generally and in animal studies.

Introduction
Incidence of global warming have resulted into heat stress, adversely affecting animal health and performance. Application of phytogenic bioactive components, such as the ones found in ginger has proven positive, this is because ginger (Zingiber officinale Roscoe) contains gingerols, specifically 6-gingerol, which is an active compound, noted to contain strong antioxidant activity. However, the instability of phytonutrients in the gut necessitated adoption of nanotechnology, incorporated into phytochemistry to ameliorate heat stress and improve animal performance.

Objective
This research was conducted to evaluate the effectiveness of nano-encapsulated ethanolic ginger extract on the physiological response, oxidative status and hormones of rabbit does in the tropics.

Materials and methods
Shade-dried sliced ginger root was blended and extracted with ethanol, following the method by Mounier et al. (2021). Nano-encapsulation was accomplished via El-Desoky et al. (2021) methodology. Sixty-four nulliparous (7-months-old) pure line breeders (New Zealand White Rabbit does), averagely weighing 23 kg, aged between four to six (4–6) months were used. Experimental does were randomly allocated to four treatment groups at 16 does per treatment. Experimental design is as follows; Group 1 received 3 mls of water, Group 2 - 50 mg/kg body weight of non-encapsulated ginger extract in 3 mls of water. Group 3- 10 mg/kg body weight of nano-encapsulated ginger extract in 3 mls of water. Group 4- 25 mg/kg body weight of nano-encapsulated ginger extract in 3 mls of water. Blood was collected via marginal ear vein, serum separated through centrifugation. triodothyronine, tetraiodothyronine and luteinizing hormone were analyzed using commercial solid-phase enzyme immuno-assay kits. All data collected were statistically analysed using One-way analysis of variance (ANOVA) and Descriptive statistical analysis method and mean were separated using Duncan Multiple Range Test.

Results
It was noted that at week 4, respiratory rate, ear temperature, heart rate and rectal temperature (100.25 ± 1.47, 100.44 ± 1.45, 24.66 ± 1.30, and 24.76 ± 1.37) were significantly ($P < 0.05$) lowered in treatment group 4, administered with 25 mg/kg nano-encapsulated ginger, in comparison to other treatment groups. All oxidative parameters evaluated were not significantly influenced by the experimental supple-

mentation of nano-encapsulated ginger. However, 10 mg/kg body weight of nano-encapsulated ginger administration lmproved the luteinizing hormone concentration of test animals under treatment group 3.

Conclusions
10 mg/kg and or 25 mg/kg nano-encapsulated ginger could be administered to rabbits under heat-stress condition to improve performance.

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189

Meat quality traits of growing rabbits fed graded levels of sweetpotato composite meal from two varieties

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Application
The sweetpotato composite meal is an excellent source of energy while also complementing the dietary protein requirement and could be a substitute for maize grain in the diets of rabbits

Introduction
Nigeria's population is expanding quickly, necessitating increase in the demand for affordable animal proteins for consumers. The world's grain scarcity, the skyrocketing price of maize, which is largely attributed to the disputes between Fulani livestock herders and farmers leading to loss of crops, decreased production, fatalities, higher costs for agricultural goods as well as continuous competition between humans and livestock. The disruption in production and distribution channels of maize largely from the Northern Nigeria necessitates the search for alternative, non-traditional feed ingredients that can replace maize in animal's diet. Sweetpotato is grown in all ecological zones in Nigeria.

Materials and methods
Eighty-four 35-day old crossbreed (Chinchilla × New Zealand White) weaned doe rabbits weighing 570.76 ± 42.09 g were allotted to five dietary treatments (12 rabbits/treatment; 4 rabbits/replicate). Maize was replaced at graded levels in the diet. The diets were designated as T1-control (0 %), 25, 50% of orange flesh sweet potato composite meal were T2 and T3, respectively, and 25 and 50 % of white flesh sweet potato composite meal were T4 and T5 respectively. Ingredients and chemical composition of diets are reported in Olaleru and Abu (2021). The experiment was carried out in a completely randomized design and lasted for 63 days. At the end of the feeding trial, meat quality characteristics were determined by sampling four rabbits from each treatment weighed, starved overnight but offered water, stunned, and slaughtered. The AOAC (1995) procedure was used to determine the proximate composition of the meat sample. Meat pH was determined using a portable pH meter (RadioMeter Analytical, France) equipped with pHC3031-9 spear shaped electrode. Colour was measured with Minolta Chromameter 300 (Minolta Co., Ltd., Osaka, Japan) using light source D65 and 8 mm Ø measuring area, diffuse illumination and 0° viewing angle. The equipment was calibrated to white plate before each session of measurements. The CIELAB L* (lightness) a* and b* (green-red and blue-yellow chromaticity coordinates, resp.) colour space was used to determine the colour; C* (chroma) was calculated using the equations given in the equipment's Instructional Manual. Data collected were subjected to analysis of variance (ANOVA) and significant means were separated by Duncan Multiple Range Test using SPSS statistical software package 2011, version 20.

Results
A significant difference was observed in the proximate composition of meat. There were no significant differences in the pH across all treatments. The levels of meat lightness (L*) and levels of redness (a*) were unaffected by test ingredients. However, there was a significant difference in yellowness (b*) and chroma (c*). In the current investigation, the pH levels among the treatments were similar, which led to comparable lightness (L*) and values among treatments. The inclusion of the composite sweetpotato meal had no effect on the meat's immediate composition, but moisture content, fat and ash content were significantly different across the dietary treatments.

Conclusions
The overall meat quality was not affected by the level of inclusion of the two varieties of composite sweetpotato meal.

References

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