A pilot project to evaluate key performance indicators for suckler herds and growing and finishing beef enterprises in England

Sarah Hewitt BSc BVetMed MRCVS

Supervisors: Dr Chris Hudson, Professor Martin Green

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Executive Summary

- Key performance indicators (KPIs) can be described as physical or financial metrics used to predict overall business success. They are widely used across many industries to monitor the efficiency of production, identify potential areas for improvement, and measure progress towards reaching specified goals. Financial margins in the beef industry indicate that optimising efficiency is important in maintaining a sustainable business financially, but improving efficiency can also be beneficial from an environmental and animal health perspective.
- A literature review was conducted (see separate document) to assess KPIs currently used to monitor performance of beef herds both in the UK and abroad. KPIs employed in the UK tend to be designed for suckler herds (rather than growers or finishers), and mainly involve physical performance indicators. In other big beef producing countries however, KPIs tend to incorporate financial data to a greater degree. It has been suggested that although farmers are often more willing to benchmark production measures, financial information is also important as the best production performance doesn't always correlate with the best financial performance. KPIs used in different sectors (dairy, pork and poultry) were evaluated, and metrics to monitor growth and carcase classification performance, animal health and infectious disease status, and environmental impact were also investigated. The evidence base around KPIs for the beef industry is limited, largely due to the challenges presented by complex farm systems consisting of many confounding variables. During this project mathematical modelling aims to address some of these challenges.
- A technical advisory group (TAG), consisting of beef farmers, beef advisors, University of Nottingham academics and AHDB staff, was co-ordinated to guide the project and ensure that the outputs are relevant at the farmer and advisor level. The group met quarterly to discuss KPI use in beef enterprises, for example what KPIs are used in the various enterprises, what data is required to calculate these metrics, and how easy that data is to capture. Several common themes were highlighted during TAG discussions:

- The importance of weighing animals regularly in monitoring performance.
- How use of electronic identification (EID) can aid data capture.
- The amount of data that already exists and has the potential for use in performance monitoring if recorded and stored in an appropriate way.
- How analysing data distributions (and looking beyond an average value) can allow best use of data to be made.
- The importance of being able to analyse physical and financial data together, and so link one to the other, in appraising enterprise success.
- Fixed and overhead costs were identified as the biggest drivers of profitability, and so cost of production was discussed as a potential marker of enterprise success.
- The diversity of the beef industry, and the need for KPIs to be relevant to an enterprise and to reflect its individual goals was discussed. This led to the development of a KPI toolkit, structured in a hierarchical way with comprehensive KPIs (incorporating multiple aspects of production) at the top, and more specific performance indicators underneath (Figure 1).

- Farmers in the group provided herd performance data for analysis, which as well as providing case studies and material for knowledge exchange activities, also allowed investigations into ways of best displaying data for use in herd management decision-making. Details of these key outcomes of the TAG are provided in the main report. Where possible, more detailed analysis of farm data was performed to investigate predictors of certain elements of performance, for example DLWG. In this example, a single antibiotic treatment was associated with a DLWG reduction of 0.123kg, and receiving two antibiotic treatments was associated with a DLWG reduction of 0.279kg.
- Further statistical analysis was used to investigate the effect of multiple variables on an outcome simultaneously, using a larger dataset obtained from the AHDB Stocktake database. 56 suckler enterprises and 36 grower/finisher enterprises that recorded in 2013, 2014 and 2015 were analysed to investigate the relationship between physical and financial performance indicators and enterprise success

(defined as net margin/cow bred for suckler herds, and net margin/ head of output for grower/finisher herds). Several significant associations were identified in the suckler herd dataset, both in the physical performance indicator model and the financial performance indicator model. For example, an increase in DLWG to weaning of 0.1kg was associated with an increase in net margin/cow bred of £18.86. Although no significant associations between physical performance indicators and net margin/head output in the grower/finisher dataset were identified, the model did illustrate significant associations of net margin/head of output with several financial performance indicators. For example, each £ decrease in labour cost/cow bred was associated with an increase in net margin/cow bred of £1.11. The lack of clarity in the physical performance indicator model is probably due to there being too few data points and there being too much 'noise' (i.e. too many other things introducing variation). Further analysis using alternative statistical techniques will be investigated in order to analyse this data further. Simulation modelling is also particularly useful in these situations, and this method will be investigated to further clarify these relationships during the second part of the project

- Through discussion with the TAG, and distribution of a questionnaire, farmer attitudes to data collection and analysis were evaluated, and perceived challenges investigated. Farmers questioned tended to value their data highly, and many would like to record more, or make better use of what they currently collect. Almost half of respondents use herd management software, but over 50% of these commented on aspects of their software that could be improved to better meet their needs. Data analysis appeared to be viewed as slightly more challenging than data collection by respondents, indicating that this could be an area where increased guidance for farmers could be particularly effective in overcoming challenges to data use. Other than cost and time, lack of technology and knowledge were commonly quoted barriers to data collection and use.
- The outputs from TAG discussion and data analysis, and the questionnaire appraising attitudes and perceived challenges to data collection and analysis, were fed back to herd management software providers with the aim of facilitating the industry in allowing farmers to make the best use of their data for effective decision-making.

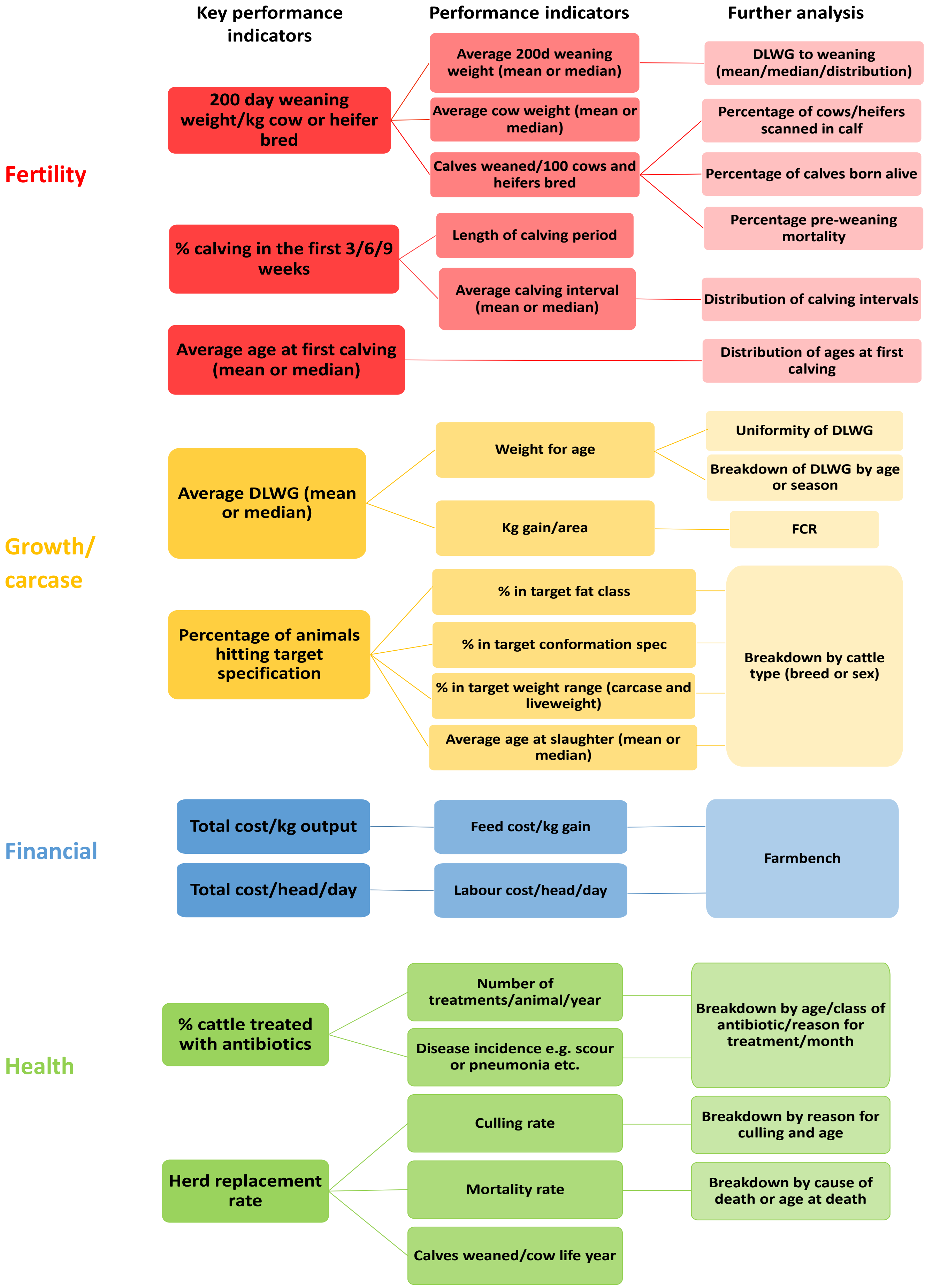

Figure 1: Beef KPI toolkit developed through discussion with the TAG

Key messages for producers and industry

- Optimising efficiency of production through performance monitoring can be used to facilitate both financial and environmental sustainability of beef enterprises.

- Use of KPIs that reflect the targets of an enterprise can enable goals to be achieved. Goals are often financial, for example to optimise net margin (i.e. profit), however producers will often have more immediate control over physical aspects of production. The ability to link physical performance data with financial, and to analyse both aspects of production together, can allow more complete monitoring of enterprise performance and enable more effective decision-making than monitoring either aspect in isolation.

- Data is often recorded and not used for performance monitoring, for example statutory movement data and medicine use data. Recording and storage of such data in an appropriate format and in a single place (data is often stored in multiple places making analysis challenging), could facilitate increased performance monitoring.

- The evidence base behind KPIs used in beef production is limited. This is largely due to the many confounding factors in a farm 'system' all having various and interacting effects on production, and challenges around generation of sufficiently large datasets that would enable statistically significant conclusions to be drawn. During this project mathematical modelling has been used to determine individual and independent effects for many variables on an output (for example net margin), and to account for some of these confounding effects. Going forward, simulation modelling will be used to further investigate these relationships.

- Through discussion with a technical advisory group (TAG), a KPI toolkit has been developed, structured in a hierarchical fashion to provide a decision-making pathway. Definitions of the performance indicators in the toolkit have been provided to facilitate consistency of use.

- Many of the performance indicators in the toolkit require weight data. The importance of capturing weight data regularly was highlighted as important by the TAG, and the use of EID was seen as a way of facilitating this. EID was also seen as a way of enabling the flow of data along the supply chain both between producers and to the processor, and back again to the primary producer, allowing an individual animals data to be used at all stages of production.

- During analysis of TAG farm data, methods of displaying data were investigated. Those that displayed data distribution, rather than an individual average figure, were felt to be particularly useful.

- A questionnaire was distributed to appraise farmer attitudes to data collection and analysis. This highlighted that farmers value their data, and many questioned would like to collect more or make better use of what data they have. Data analysis was perceived as slightly more challenging than data collection, and highlights an area where increased support for farmers could facilitate performance recording. Other than time and cost, lack of technology and knowledge were commonly quoted barriers to data collection and use.

- Relevant outcomes of TAG discussion and questionnaire results were fed back to herd management software providers, with the aim of promoting ways in which farmers feel their software could enable them to make best use of their data.

- Throughout the project KE activities have been held to demonstrate how data can be used to inform herd management decision-making, and to engage with beef farmers around data capture and use.

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Introduction

Key performance indicators (KPIs) are widely used across many industries to inform decision-making and monitor efficiency of production. Financial margins in the beef industry have been decreasing over recent years meaning that efficient production is becoming ever more important to sustainability. On average between May 2015 and May 2016 the price paid per kilogram of beef in the UK has been one of the highest in Europe (European Commission, 2016a), and yet even the top herds are struggling to make a net profit (AHDB Beef and Lamb, 2015). In addition to financial pressures, there is increased interest in improving efficiency in order to reduce the environmental impact of farming. Although widely used in the dairy, pork and poultry industries, use of KPIs in the beef sector has tended to be more limited.

KPIs currently used in suckler and grower/finisher enterprises in England, as well as those used in other major beef producing countries, have been assessed in a literature review (see separate document). In addition, KPIs from other sectors such as dairy, pork and poultry, which may be applicable to beef units, have been evaluated. The industry standard beef herd KPIs in this country largely focus on fertility parameters, and are designed to monitor suckler herd performance. KPIs used in the poultry, and to some extent the pork sector, focus less on fertility and more on growth and mortality rates, so may be of relevance to grower/finisher beef enterprises. KPIs used on beef units in other major beef producing countries, such as the USA and Brazil, appear to incorporate financial parameters to a greater degree than commonly used KPIs in this country. Such KPIs may be relevant in monitoring the success of both suckler and grower/finisher enterprises in England.

Aims and objectives

In collaboration with the Agricultural and Horticulture Development Board (AHDB) Beef and Lamb, this project aims to add significant information towards the development of KPIs for the beef industry in England. The first 18 months (January 2016 to June 2017) of the project involved:

- Evaluating current measures used and investigating potential new KPIs.

- Assessing farmers’ attitudes towards data recording and perceived barriers to performance monitoring, as well as seeking potential solutions to these problems.
- Formation of a technical advisory group (TAG) consisting of 4 well recorded beef farmers, 4 technical advisors with a recognised interest in measuring performance, AHDB staff, and University of Nottingham academics.
- Calculation of KPIs and outlines of trends using TAG farmer production data.
- Analysis of correlations between KPIs and overall farm success using production and financial data from AHDB Stocktake database.
- Knowledge exchange activities including farm case studies, articles, and on farm events.

The second part of the project (July 2017 to September 2018) will involve:

- Use of stochastic modelling and statistical techniques to further define KPIs in relation to overall enterprise success.
- By investigating more complex scenarios, the impact of management changes on overall enterprise success will be further clarified in the different systems. This will help farmers and advisors decide which the most important KPIs for an enterprise are at that time.
- It is anticipated that the TAG will remain involved during the second part of the project to provide guidance on this aspect of the project.

Formation of a beef KPI technical advisory group (TAG) and summary of meetings

Role of the technical advisory group

The aim of this project is to add significant information towards the development of KPIs in the beef industry in England. Whilst also being relevant to the success of an enterprise, the data required to calculate KPIs must be realistically able to be captured routinely and reliably. A beef KPI technical advisory group was formed, consisting of beef farmers, beef advisors, AHDB staff and academics from the University of Nottingham, to guide the project, and to ensure that outputs are relevant at the farmer and advisor level. The co-ordination of the TAG was a crucial part of the project, allowing discussion around the use of KPIs and data recording. Identification of potential TAG members was carried out in collaboration with AHDB staff, with the aim of incorporating as many aspects of the beef industry as possible. Through six quarterly one day meetings, the TAG guided the project, providing farm 'case-studies' and industry messages to promote the recording of data and use of KPIs, as well as providing a foundation on which to base the stochastic modelling planned for the second part of the project. The objectives of the TAG were:

- To advise farmers and advisors on issues around data collection and KPIs.
- To guide the academic team so that data is analysed and interpreted appropriately.
- To identify barriers to data collection and develop possible solutions.
- To advise on new ways of collecting, analysing, and interpreting data.

Co-ordination of the TAG

The TAG consists of four well recorded beef farmers (two sucklers, one grower finisher, and one finisher), four beef advisors (three vets with an interest and expertise in the beef sector and a consultant), University of Nottingham academics, and AHDB staff. Potential TAG members were identified in collaboration with AHDB staff. Four farmers were selected with the aim of incorporating suckler and grower/finisher enterprises, upland and lowland systems, and intensive and extensive systems.

Farmers needed to have an interest in data recording, and good historic data. They also had to be willing to provide data (both physical and financial), attend regular meetings, and to host two on farm events per farm. Advisors were also selected in collaboration with AHDB with the aim of including vets, consultants and nutritionists. A long list was drawn up and prioritised, and individuals were contacted in order to ascertain their interest in involvement in the project. Four advisors were recruited; three vets and a consultant with an interest in nutrition. In order to ensure an initial wide spectrum of input, and to allow involvement of beef experts without the time to commit to quarterly meetings, an extra group (TAG plus) was formed. TAG meetings were held quarterly from January 2016 to May 2017, with TAG plus members attending the first and final meetings.

Summary of meeting outputs

TAG meetings were held quarterly, with TAG plus members attending the first and final meetings. The timings, attendees, objectives and outcomes of the meetings are summarised in table 1.

Meeting Date	Attendees	Venue	Objectives and outcomes
27th January 2016	TAG and TAG plus	University of Nottingham	**Objective:** Small group discussion around KPIs currently used, KPIs that the TAG would like to use but currently don't, and KPIs the TAG feel should be avoided. **Outcome:** A provisional list of KPIs grouped into 4 categories depending on what aspect of performance they measure. Development of a KPI toolkit allowing farmers and advisors to select relevant KPIs suggested.
27th April 2016	TAG	University of Nottingham	**Objective:** Small group discussion on data required to calculate suggested KPIs, how easy or difficult that data may be to capture, and where it might already exist. Also discussed a definition for enterprise success. **Outcome:** Enterprise success defined as net margin/cow bred for suckler herds and net margin/head of output for grower/finisher herds. List of data required to calculate KPIs generated and used to collect data from TAG farmers.
20th July 2016	TAG	Tele-conference	**Objective:** Discussion around prioritisation of suggested KPIs to provide structure to the toolkit. **Outcome:** TAG members prioritised KPIs and began to develop a KPI hierarchy.
19th October 2016	TAG	University of Nottingham	**Objective:** Summary of TAG farmer data analysis and discussion around ways of displaying data.

			Outcome: TAG found displaying distributions of data useful in data analysis.
23rd January 2017	TAG	University of Nottingham	**Objective:** Discussion around scoring KPIs and structuring them into a hierarchy to form the KPI toolkit. Definitions of KPIs and ways of presenting them also discussed. **Outcome:** Consensus reached on how KPIs were scored and ranked, and how they should be presented in the toolkit.
19th May 2017	TAG, some TAG plus and software providers	NEA, Stoneleigh	**Objective:** Presentation of findings to software providers including suggestions on what KPIs the TAG felt were important, and how they could be presented, using examples of TAG farmer data. **Outcome:** Software providers keen to maintain dialogue with farmers and advisors as to how they can enable farmers to make best use of their data.

Table 1: TAG meetings summary

Development of a KPI toolkit

One of the first points raised during TAG discussion was that the diversity of the beef industry makes it impossible to define a ‘blue print’ of KPIs that will be the most relevant for all beef enterprises. This led to the development of a KPI toolkit (Figure 3), containing performance indicators felt to be important by the group, and with definitions of these indicators to aid standardisation of their use (Figure 4). Performance indicators were suggested by the TAG and grouped into the following categories depending on which part of the system they monitored (although there is inevitably some overlap): Fertility, Growth and Carcase, Financial, and Health. They were then scored against characteristics of a good KPI (through discussion with the TAG), and ranked. These characteristics were defined again through discussion with the TAG and using the following sources: (D'Arcy, 2015) and (The KPI Institue, 2015). These characteristics were that a KPI should be:

- Measurable
- Actionable
- Easy to understand
- Timely
- Relevance to efficiency (i.e. incorporating inputs and outputs)
- Comprehensive/specific (as required)
- Relevant to enterprises goals

KPIs were labelled as comprehensive (i.e. monitoring several parts of the system), or specific (i.e. monitoring only one aspect), but this was not used for ranking as it was felt that the importance of whether an indicator was comprehensive or specific would vary depending on the goals of the enterprise. They were also not scored on their relevance to an enterprise's goals, as again this will vary with the specific goals of an individual enterprise. Some characteristics were felt to be more important than others (measurable > actionable and easy to understand>timely and relevance to efficiency), so scores for these characteristics were weighted accordingly. Following ranking of the performance indicators, it was found that the more comprehensive indicators, monitoring more than one part of the system (e.g. fertility and growth), tended to score the highest. This allowed them to be arranged in a hierarchical fashion, with comprehensive performance indicators at the top, and more specific performance indicators underneath. Further data analysis suggestions were also included below these, for example evaluating seasonal variation in performance. This provides a pathway through which producers can monitor overall performance using comprehensive KPIs, but also drill down into their data using the more specific performance indicators and further analysis suggestions to pin-point areas where productivity could be improved. In the example below (Figure 2), 200day weaning weight/kg cow or heifer bulled is the comprehensive KPI, which can be broken down into more specific performance indicators such as the number of calves weaned, the weight of these calves, and the size of the cows. These performance indicators can be further analysed by looking at when calves are 'lost' i.e. is it through poor fertility (using scanning %), is it difficult calvings/abortions (using % calves born alive), or is it through high calf mortality rates (using pre-weaning mortality rate). Further analysis can also include looking at the distribution of the data, for example looking at how much variation there is away from the average value, and what the minimum and maximum values are.

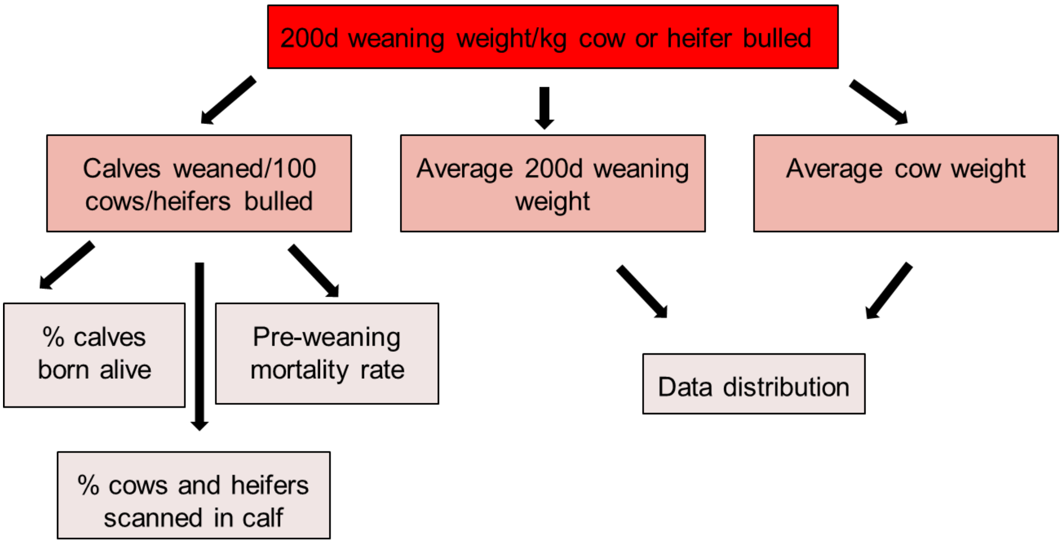


Figure 2: Example of a KPI hierarchy

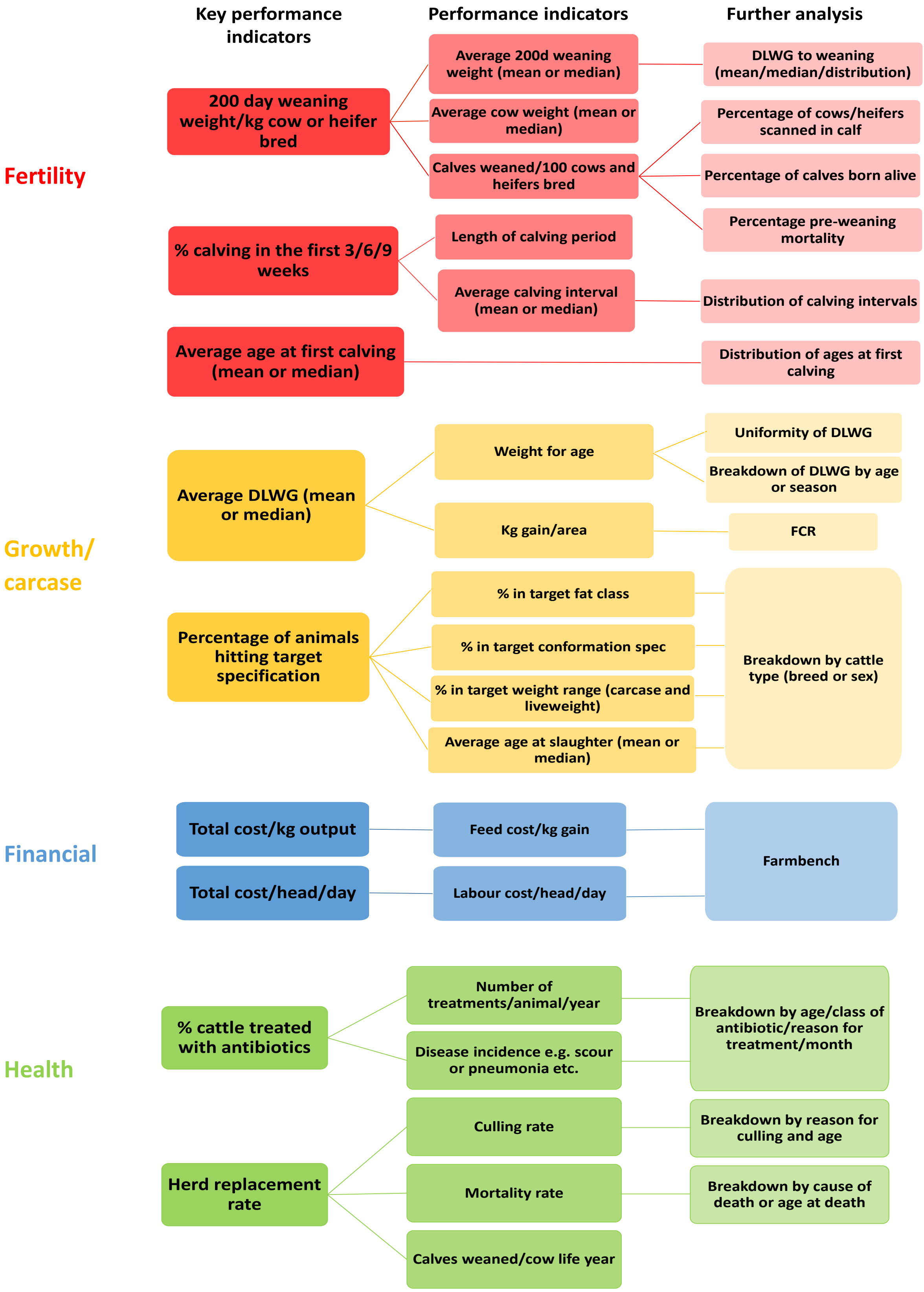


Figure 3: KPI Toolkit

Fertility		
KPI	**200d weaning weight/kg cow or heifer bred**	Total adjusted 200d kgs of weaned calf / total kgs of cows and heifers bred
	% calving in the first 3/6/9w of the calving period	(Number of cows and heifers calved in the first 3 weeks/number of cows and heifers bred) x 100 *(start of calving period calculated from bull in date plus a defined gestation length, or by looking at distribution of calving dates where more appropriate)*
	Average age at first calving	Mean or median herd age at first calving.
Performance indicator	**Calves weaned/100 cows and heifers bred**	(Number of calves weaned/number of cows and heifers bred) x 100
	Average 200d weaning weight	Mean or median 200d adjusted weaning weight (weaning weight(kg)/age in days x 200)
	Average cow weight (mean or median may be used)	Mean or median cow weight (kg)
	Length of calving period	Number of weeks between start and end of calving period *(start of calving period calculated from bull in date plus a defined gestation length, or by looking at distribution of calving dates where more appropriate)*
	Average calving interval (mean or median may be used)	Mean or median of the herd calving interval (number of days between two consecutive calvings)
Further analysis	**Percentage of cows/heifers scanned in calf (%)**	(Number of cows and heifers scanned in-calf/number of cows and heifers bred) x 100
	Percentage of calves born alive	(Number of calves born alive/number of cows and heifers bred) x 100
	Percentage pre-weaning mortality	(Number of pre-weaning deaths/number of animals born alive) x 100
	DLWG to weaning	Mean, median or distribution of DLWG (kg) values up to weaning
	Distribution of calving intervals	Distribution of calving intervals
	Distribution of ages at first calving	Distribution of ages at first calving
Growth and carcase		
KPI	**Average DLWG**	(Current weight of animal(kg)-previous weight of animal(kg))/number of days between weighings. Mean, median or distribution DLWGs may be used.
	% of animals hitting animal target spec	(Number of animals hitting target spec/total number of animals finished) x 100
Performance indicator	**Weight for age**	Weight of animal (kg)/age in days of animal
	Kg gain/area	Total kg gain of group/area grazed by group
	% in target weight range (carcase and liveweight)	(Number of animals hitting target weight range/total number finished) x 100
	% in target fat class	(Number of animals hitting target fat class/total number finished) x 100
	% in target conformation spec	(Number of animals hitting target conformation sec/total number finished) x 100
	Average age at slaughter	Mean or median age of animals finished in a year
Further analysis	**Uniformity of DLWG**	Proportion of variation in individual animal weight explained by age at weighing
	Breakdown of DLWG by age or season	Average DLWG (kg) in each month/age group.

	Average age at slaughter for heifers/steers/bulls (mean or median may be used)	Average age at slaughter for heifers/steers/bulls.
	FCR	Total kg DMI of group/Total kg gained by group
	Financial	
KPI	**Total cost/kg output**	Total cost (fixed and variable)/total kgs produced. Sucklers total kgs = total 200d weaning weights. Stores total kgs = total liveweight sold. Finishers = total deadweight or liveweight sold.
	Total cost/head/day	Total cost (fixed and variable)/head of animal/day (number of breeding cows for suckler enterprises, average herd size for store or finisher enterprises)
Performance indicator	**Feed cost/kg gain**	Total feed cost/(finished liveweight-birth weight or purchase weight)
	Labour cost/head/day	Total labour cost (including imputed family labour)/head of animal/day (number of breeding cows for suckler enterprises, average herd size for store or finisher enterprises)
Further analysis	**Stocktake/Farmbench**	Further financial analysis available through use of AHDBs Stocktake/Farmbench service
	Health	
KPI	**% cattle treated with antibiotics**	(Number of animals treated with antibiotics/total herd size) x 100
	Herd replacement rate	(Number of cows deaths + number of cows and calved heifers culled)/(number of cows and heifers put to the bull)) x 100 (include any cows sold for breeding in the numerator)
Performance indicator	**Number of antibiotic treatments/animal/year**	Number of antibiotic treatments (long acting injection or course) during a year/total herd size
	Disease incidence e.g. scour or pneumonia etc.	Number of cases per year/herd size for each disease.
	Culling rate	Number of animals culled / total herd size
	% cow mortality	(Number of cow deaths/total herd size) x 100
	Calves weaned/cow life year	Number of calves reared to weaning by a cow/the age of the cow in years (an average, mean or median as appropriate, can be calculated for animals leaving the herd, or for the whole breeding herd, depending on the aims of the enterprise)
Further analysis	**Breakdown by age/class of antibiotic/reason for treatment/month.**	Proportion of antibiotic treatment rate, or disease incidence rate, that each age group/class of antibiotic/reason for treatment/month contributes.
	Breakdown by reason for culling and age	Proportion of culling rate that each reason for culling/age category contributes.
	Breakdown by cause of death or age at death	Proportion of mortality rate that each cause of death/age group contributes.
Herd size: Suckler herd size = total number of animals that have been on the holding during the year, grower/finisher herd size = average herd size/total number of animals that have been on the holding during the year/number of cattle days as appropriate.		

Figure 4: KPI Toolkit definitions

Data availability and barriers to recording and use

Through discussion with the TAG, several points regarding data availability and perceived barriers to monitoring performance and KPI use were raised:

- Many KPIs require weight data, however weighing is not something routinely carried out on many beef farms. In addition, the TAG reports that some farmers that do weigh their animals don't record this information, for example they weigh to identify outliers.
- Electronic identification (EID) was identified as being of huge benefit in recording data, as was the availability of a good handling system.
- The need for a more integrated supply chain, with greater feedback of data along the chain, was highlighted as a priority.
- It was acknowledged that data for many KPIs will be recorded somewhere, for example in BCMS, medicine records, accounts, or kill sheets. It was suggested that the main barrier to using this data was compatibility between systems. Problems getting herd management software to integrate with accounting software were reported, and a need for flexible reporting systems, able to produce management and financial reports, was expressed. Herd management software was also described as too complex and not user-friendly enough by some TAG members.
- It was suggested that farmers tend to be better at measuring production parameters than financial parameters, which led to a discussion about how important financial parameters are to them. The idea that some farmers express more pride in a healthy herd than a profitable herd was suggested.

These aspects were further explored through collecting wider opinion from a larger set of farmers through a questionnaire (as discussed in a following section).

Discussion around how software can best enable farmers to make best use of their data

Throughout TAG discussions several themes emerged around beef herd data collection and analysis that it was felt would be useful to share with herd management software providers, so the final TAG meeting incorporated several representatives from herd management software provider companies. It was also felt that any feedback on the challenges faced by software providers in developing these programmes for beef and sheep producers would be of use for the project, and the industry. During this meeting the following points were discussed.

- Outlier values are important to identify as they can have large effects on average values. The TAG felt that a method of error checking when entering data would be useful, or a way of excluding extreme values before analysis.
- Being able to display distributions of data, and provide summary figures other than the mean (such as median or range) was felt to be important by the TAG. Different types of graphs for displaying data distributions, such as histograms and box and whisker plots, were discussed. The ability of graphs to display seasonal variations in performance was also felt to be useful by the TAG.
- Defining a herd size or a 'population at risk' when calculating rates (e.g. treatment rates/mortality rates) can be challenging in enterprises where cattle are frequently being bought and sold and may stay on the unit for variable periods of time. In this instance the use of cattle-years as a denominator (rather than an average herd size) may be more appropriate.
- Targets should be adjustable so that they can be tailored to an individual enterprise's current performance and realistic performance goals.
- How the data is displayed and broken down should also be adaptable, e.g. treatment rate could be analysed by month/year/disease treated/type of antibiotic used/age of animal etc.
- Standardised data entry aids analysis. For example, providing tick box options for reasons for treatments/causes of death, rather than free text input, provides discrete categories for analysis.
- A consistent file format across different software types could help allow data to travel with an animal from birth to slaughter, and back along the supply chain from processors back to producers. It was felt that data sharing in this way would be of benefit for the industry.
- Farmers often have to record data in multiple places, increasing risk of human error and time commitment from farmers. Although recognised that herd

management software is increasingly incorporating pre-existing data, it was felt that data transfer in both directions, i.e. into and out of software, would be beneficial. Compatibility between different software packages, for example those recording physical data and those recording financial data, so that both can be analysed together, was also felt to be beneficial.

- Some specific pieces of data were required to calculate certain KPIs that it was felt may not be routinely recorded by software packages. For example, a 'predicted start of calving date' is required for calculating the percentage calving in the first 3/6/9 weeks of the calving period, and the number of cattle on an enterprise each day is required to calculate the number of cattle-years for use as a population denominator when calculating rates.

- A questionnaire distributed to collect a wider opinion around perceived challenges to data collection and analysis highlighted aspects of software that farmers liked, which included ease of data entry, the way data is displayed and the reports generated. When asked what they would change, respondents would like additions to be made to the standard reports available, to allow remote data recording (e.g. crush-side) and for data to be stored in the cloud, and for software to be compatible with other systems (for example accounting systems). It also illustrated that farmers value their data, and many would like to record more or make better use of what they currently collect. Almost half of respondents used herd management software, but over 50% of these commented on aspects that could be improved to better meet their needs. Data analysis appears to be viewed as slightly more challenging than collection, and other than time and cost, lack of technology and knowledge were commonly quoted challenges to data collection and use.

Definition of enterprise success

One of the aims of this project is to analyse correlations between KPIs and overall enterprise success. In order to do this a definition of enterprise success is required. Through discussion at TAG meetings, it was accepted that there was not one definition that would define enterprise success for every type of beef herd. Whilst physical factors may show success in some areas, they may come at increased cost and so lower profitability, and vice versa. It was therefore decided that the definition should include financial parameters. Fixed and overhead costs were identified as the biggest drivers of profitability, and so cost of production was discussed as a potential marker of enterprise success. It was acknowledged however that inputs can also be volatile and should be accounted for. Net margin, i.e. the difference between costs and revenue, incorporates both inputs and outputs and is a commonly used financial metric in other sectors. It was decided that it should ideally be calculated on a full economic basis (i.e. incorporating both fixed and variable costs), although the possibility of evaluating KPIs in relation to fixed and variable costs separately was also discussed.

Discussion

Some of the points raised during TAG discussion do not relate directly to beef KPIs, but to the beef industry in general, such as the importance of an integrated supply chain. However, it was felt that these points were useful to discuss in order to put the use of data within the English beef industry in context. The compatibility of herd management software, both between and within programmes (i.e. the ability to generate reports incorporating physical and financial parameters) was also highlighted as an industry problem.

Many of the KPIs suggested during the TAG meetings involve weight data, and both cow and calf weights are a common component of measures of cow efficiency (Roughsedge et al., 2003). Weighing is not however routinely carried out on many beef farms. Increasing availability of weigh scales through loan schemes via local vets or agricultural merchants was suggested by the TAG as a way of increasing weight data recording. Weighing animals at markets would also increase the amount of weight data available, as well as providing a greater degree of transparency at purchase and sale. This practice is common in some areas but not countrywide. EID was highlighted by the TAG as being helpful in allowing regular weight monitoring, as well as being hugely beneficial for data recording in general. EID has been compulsory in breeding sheep in the EU since 2010 (European Commission, 2016b), and is mandatory in cattle in Denmark (Danish Veterinary and Food Administration, 2015), with many other governments considering a similar policy. Barriers to adoption of EID systems proposed by the TAG include expense (although it was noted that this is decreasing), and a lack of awareness of the benefits of the technology. EID is also crucial in automated data collection, another aspect of production that the TAG felt could increase data recording and performance monitoring.

The use of already recorded mandatory data to monitor performance, such as movement and medicine records, has been highlighted as a way of introducing farmers to performance monitoring and engaging them in data recording. Data can be downloaded from BCMS and calving dates can be used to calculate indicators such as % calving in the first three weeks of the calving period, assuming the start of the breeding period is known (Borsberry, 2007). Medicine records could also be used, for example to calculate antibiotic usage, and kill sheet and invoice data could be a source of costings data, sales figures, and cattle weights and grades.

Predicting performance was highlighted by the TAG as a way of decreasing the inherent lag time that occurs between an event occurring and the data being recorded and analysed. Using pregnancy diagnosis results to calculate the % calving in the first 3/6/9 weeks of the calving period was highlighted as a way of monitoring current fertility, rather than fertility 9 months previously. A similar concept has been suggested for the poultry industry, with the use of 'lead' and 'lag' KPIs (Manning et al., 2008). 'Lead' KPIs focus on current performance and allow 'intra-crop' adjustments to be made. 'Lag' KPIs focus on more historic data meaning that changes can only be implemented for the next batch, i.e. are 'inter-crop' indicators. Using regular weight data to provide accurate daily liveweight gains (DLWG) is an example of an inter-crop indicator that can be used to make management changes to a current batch, for example to adjust feeding protocols.

An appropriate definition of enterprise success is required to allow correlation of KPIs to a single metric. It was appreciated that it was impossible to have a single best definition to cover all types of enterprise, but that an indicator incorporating financial parameters would be most appropriate. Net margin calculated on a full economic basis was chosen. This is also an indicator of sustainability which is an important aspect when businesses are operating in a volatile market. It was highlighted by the TAG that farmers tend to be better at recording physical rather than financial parameters, suggesting that this may be what motivates them. Similarly, a study looking into farmers' motivations towards lameness control found that 'pride in a healthy herd' was a bigger motivator than economic factors (Leach et al., 2010).

The use of a performance indicator hierarchy, providing a small number of comprehensive KPIs that monitor overall enterprise productivity, and a toolkit of more specific performance indicators, allowing bespoke combinations to be tailored to individual farms and problems, has been a main outcome of the TAG meetings. The second part of the project will focus on further defining how these KPIs affect overall enterprise success.

Conclusions

Several main themes emerged from the TAG meetings. These included the prioritisation of performance indicators into a hierarchy, incorporation of financial parameters into performance indicators, the importance of fertility parameters in suckler herds and of weight data in both suckler and grower/finisher herds, how compatibility of data throughout the supply chain would be of benefit, the benefits of technologies such as EID and automated data collection, and the use of data that is currently recorded elsewhere e.g. medicine records / BCMS. Many of these were further explored through distribution of a questionnaire to a larger set of farmers (see Appraisal of farmer attitudes to recording and using data).

Summary of TAG farmer data analysis

Introduction/background

Data required to calculate a provisional list of priority KPIs, defined during initial TAG meetings was requested from the four TAG farmers. Farmers were also requested to enrol on Stocktake (now Farmbench), a service provided by AHDB that allows producers to record and monitor both their financial and physical performance, and to benchmark themselves against similar farms. Each TAG farmer used different herd management software**.** Data was exported from each package into Microsoft Excel for analysis. In addition to calculation of KPIs, trends over time were assessed, for example between seasons or pre and post management changes, and variation of performance within the herd was evaluated.

Examples of TAG farm data analysis

Analysis of the TAG farm data focussed on performance indicators present in the KPI toolkit, and has been guided by discussion with the TAG. Descriptive methods were used initially to summarise the data and compare performance across months or years. This allows analysis of trends and can help inform management changes on farm, as well as allowing the effects of these changes to be monitored. These methods can also be used to explore relationships between two variables, for example daily liveweight gain (DLWG) and number of antibiotic treatments. Distribution of data has also been evaluated, and how this can affect the average has been discussed. The TAG has also discussed how best to display this data in intuitive and 'user-friendly' ways.

The 'top level' comprehensive KPIs in the toolkit are illustrated in Figure 5 in their respective categories. Where data allowed, these KPIs were calculated for each TAG farmer and trends over time evaluated. Examples of each performance indicator, from one of the TAG farms, are given below.

Fertility	Weight	Financial	Health
Cow efficiency: 200d weaning weight/kg cow or heifer bred	Average DLWG	Total cost/kg output	% cattle treated with antibiotics
% calving in the first 3/6/9weeks of the calving period	% animals hitting target specification	Total cost/head/day	Herd replacement rate
Age at first calving			

Figure 5: Key performance indicators in the toolkit developed by the TAG

Fertility

In any suckler herd fertility is key to productivity. There are many different ways of monitoring fertility, some incorporating growth rate or mortality rate measures, others more specifically focussing on fertility. The following three examples are those considered to be appropriate KPIs by the TAG, and that fitted into the KPI hierarchy structure at the top.

200d weaning weight/kg cow or heifer bred

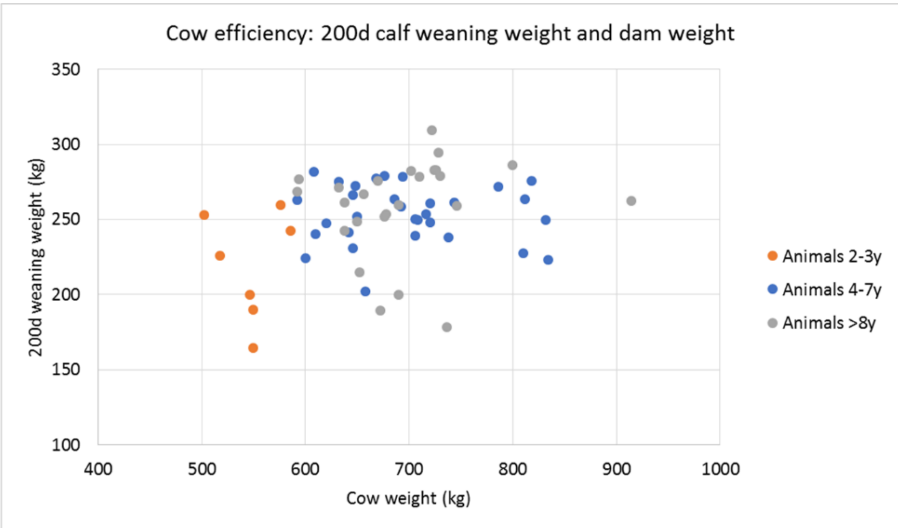


Figure 6: Example cow efficiency scatter plot for an upland suckler herd

This KPI incorporates cow fertility, cow efficiency, calf growth and calf mortality rates. It illustrates cow efficiency across the herd, but it is often more appropriate to look at it at an individual animal level to inform decision-making, as in the example above. This KPI requires cow weights in order to be calculated, and a good time to record these is at weaning. A commonly quoted target for cow efficiency is 50% (i.e. a cow weans a calf of 50% her weight), but as this doesn't suit all systems and breeds, the TAG felt it was important for this target to be adjusted according to the herds current performance and goals. The TAG also felt it would be useful to also know the age of the animal, which led to the colour coding in the example graph. This farmer is actively trying to reduce his average cow size in order to improve efficiency of the herd, and so can use this data to inform breeding and culling decisions.

% calving in the first 3/6/9w of the calving period

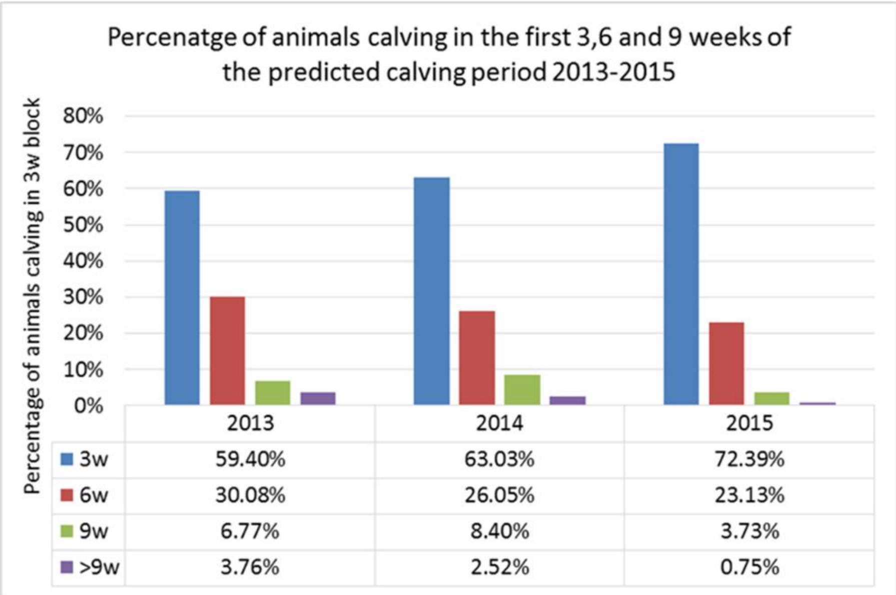
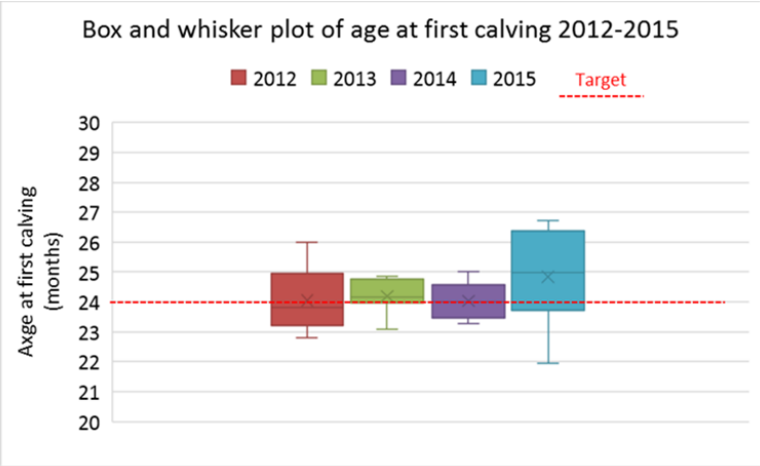


Figure 7: Example calving period bar chart for an upland suckler herd

This is a measure of fertility of the herd, and can be used to monitor the length of the calving period, and the distribution of calvings within the calving period. The TAG found this graphical representation of the percent of animals calving in the first 3,6 and 9 weeks of the calving period useful, as it allowed individual years to be evaluated as well as allowing comparison between years. It is important that the start of the calving period is calculated from the bull in/start of service date plus a defined gestation length (i.e. a predicted start of calving date), rather than using the date of the first calving, as if an animal calves early this could make the percentage of animals calving in the first 3 weeks appear artificially low. This analysis is based on calving data, i.e. the denominator is the number of animals calved. Providing the number of animals bulled, and using this as the denominator, would allow a 'barren' column to be added to the graph.

Age at first calving



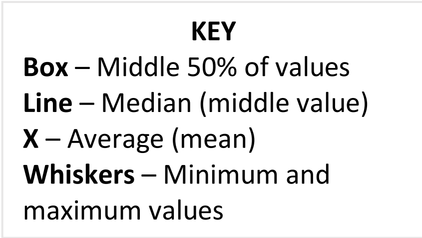


Figure 8: Example age at first calving box and whisker plot for a lowland suckler herd

Calving heifers at 2 years of age is an increasingly popular way of improving herd output, and was considered an important KPI by the TAG. Several different ways of calculating this KPI were investigated, including % of heifers calving by a target age. This however didn't give any indication of the age at first calving of the animals that didn't calve by the target age. An average age at first calving of the heifers each year would provide some indication of this, but the distribution of the ages at first calving, i.e. the maximum and minimum, and how the rest of the values are distributed between these, was considered to be very useful. This is illustrated by the box and whisker plot in Figure 8, which shows the average (mean), the middle value (median – another type of average), how close together or far apart the middle 50% of the values are (the box) and the maximum and minimum values (the whiskers). In the above example this allows us to see that although the mean value (shown by the cross) is very similar 2012 to 2014, in 2012 the spread or distribution of first calving ages was greater, and that the first calving ages for this group of animals was much tighter in 2013 and 2014. In 2015 the heifer age at first calving was again more variable, as illustrated by the larger box and extended whiskers. This was due to a problem with a new synchronisation protocol that was used. When calculating this performance indicator, it is important to consider bought in animals, as their first recorded calving on the unit may not be their actual first calving (only homebred animals were used for this analysis).

Weight

The output of any beef enterprise is kg of animal (live or dead weight), whether that be weaned calves, stores, or finished animals. The growth rate of the herd is therefore key to success, and several ways of monitoring and analysing it were discussed throughout TAG meetings. In order to monitor, and so manage, growth rates, weight data is required. The TAG felt that regular recording of weights was crucial in managing herd productivity, and that collecting this data should be encouraged across the industry. This was reflected in the questionnaire responses, where weight data was the most commonly quoted thing that respondents would like to record but currently don't. This is discussed in more detail in the 'Appraisal of farmer attitudes to recording and using data' chapter of this report.

Average DLWG – seasonal

Regular recording of weights allows seasonal patterns to be evaluated. This may be particularly useful in pasture based systems where the aim is to maximise growth from grass, as in the example below.

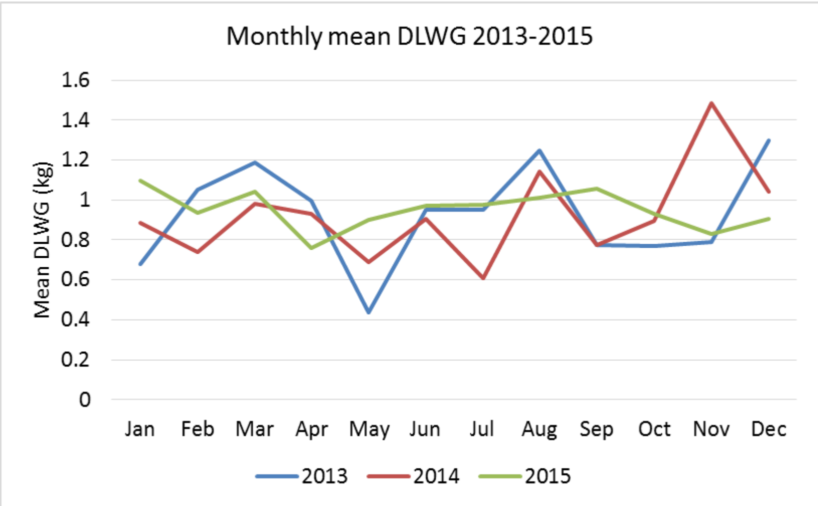


Figure 9: Example average (mean) DLWG by month line graph for a pasture based grower/finisher

Figure 9 illustrates an average drop in DLWG each year in late spring, around turnout. This is something that the farmer had been in discussion with his nutritionist about, and in spring 2014 a 'transition period' was introduced where animals were turned out gradually (initially just for a few hours), and buffer feeding was introduced to allow a more gradual diet change. This has reduced the average DLWG drop seen around turnout in spring 2014 and 2015, and overall DLWG appears to be getting more consistent across the year between 2013 and 2015.

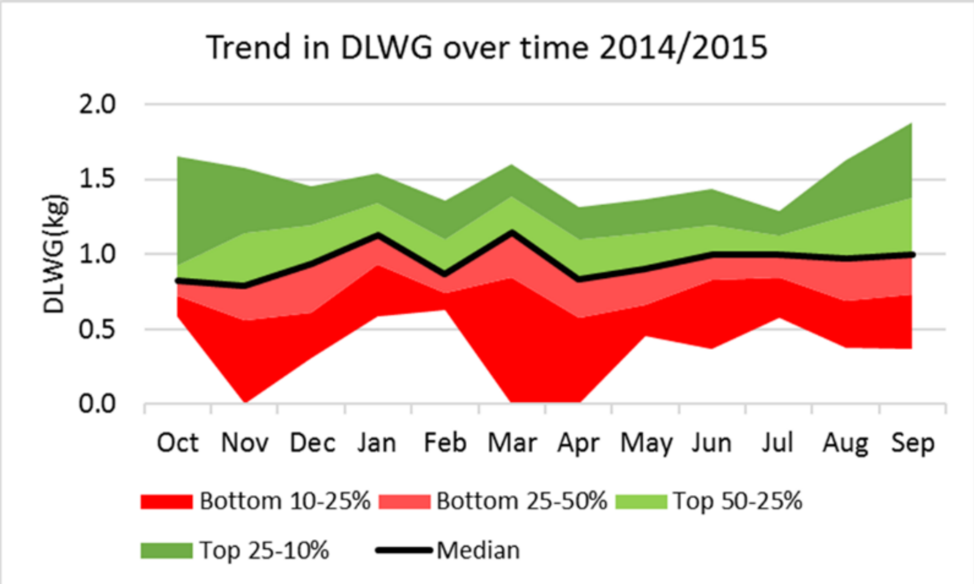


Figure 10: Example average (median) DLWG with distributions by month line graph for a pasture based grower/finisher

As previously mentioned, sometimes looking at how values are distributed around the average, rather than using a single summary figure, can provide a more complete picture of herd performance, and be more informative for decision-making. The above graph (Figure 10) is a way of displaying seasonal trends in DLWG over time (in a similar way to Figure 9), whilst also illustrating how the values are distributed around the average (here the median or middle value is used). This graph illustrates that although the average DLWG drop in late spring that was seen in 2013 has stabilised, there is still a large variation in DLWG around this time, and so still some animals not performing to their best at this time. Uniformity is an important concept in beef production, both in animals produced and growth rate across a group of animals, and this can be assessed by evaluating distribution of data.

Uniformity of DLWG

Uniform weight gain is important in allowing producers to hit target weights and specifications, and regular weighing data allows this to be analysed. Another way of assessing uniformity of growth rate is by evaluating the variation of weight at a given age across the herd or a group of animals. Weight for age has been suggested as a useful performance indicator by the TAG, particularly for grower/finisher enterprises.

In this example (Figure 11) the data is displayed in a scatter plot of age against weight, where the variation in growth rate (i.e. how far each point is from the trend line) is measured by R^2. This represents the proportion of the variation in weight which is explained by age (with 1 = all the variation), so here $R^2 = 0.906$ meaning that over 90% of the variation in weights of the animals is due to their age, with less than 10% being attributable to other factors, i.e. growth rate is very uniform. Here a calf birth weight of 35kg was assigned, but this could be varied depending on breed.

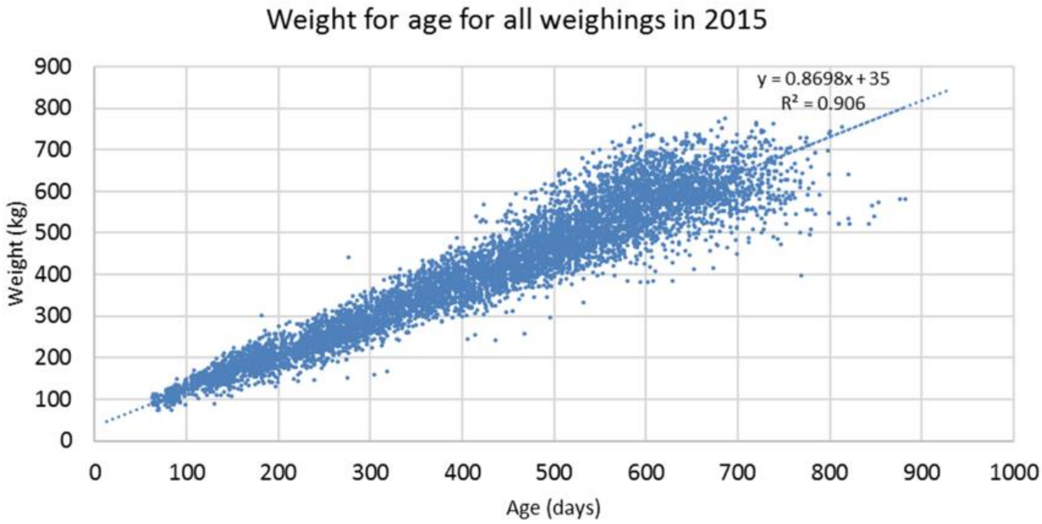


Figure 11: Example weight for age scatter plot illustrating uniformity of growth rate for a pasture based grower/finisher

Similar graphs can be drawn for individual animals (Figure 12), where the trend line can help to predict how long it will take them to reach a target weight. If processors also had access to this data it might help them to ensure consistent supply.

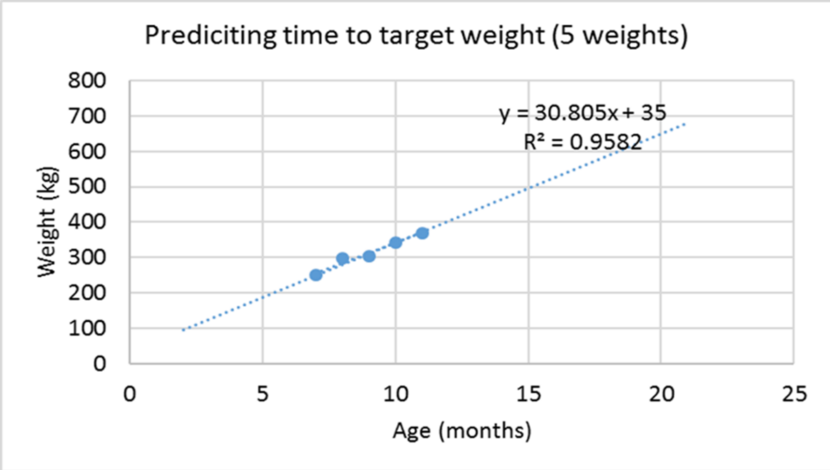


Figure 12: Example weight for age scatter plot predicting time to reach target weight for a pasture based grower/finisher

Weaning weights

A suckler herd's output is often defined as weight of weaned calves produced, therefore growth up to weaning is an important measure of herd performance. Maximising growth at an early age, when feed conversion is most efficient, is key both for producing replacements (particularly if aiming to calve heifers at 2), and for producing animals to be sold as either weaned calves, stores, or finished. Actual weaning weights can be recorded, as in the example in Figure 13, and monitored according to when in the calving period they were born. Unsurprisingly, animals born early in the calving period, which are older at weaning, tend to be heavier.

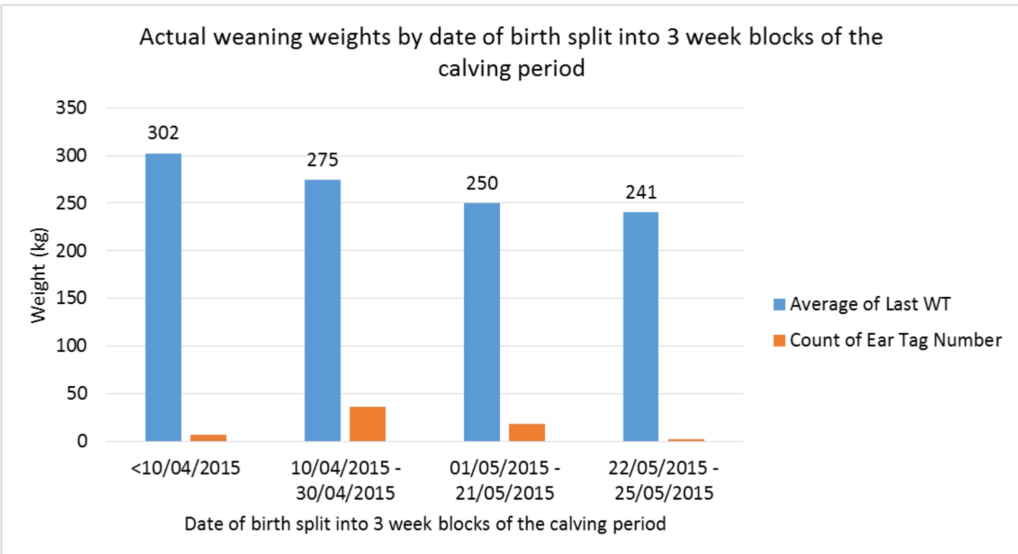


Figure 13: Example bar chart of weaning weights by date of birth in an upland suckler herd

In order to standardise weaning weights to take into account when in the calving period a calf was born, and the age at which it was weaned, weaning weights are often quoted as the weight at which the animal would have been at 200 days old (according to its current weight and age). 200 day adjusted weaning weights can also be monitored by the calf's date of birth, as in the example in Figure 14. This illustrates that calves born early on in the calving period tend to grow better, possibly due to reduced infection pressures around the start of calving and so optimal health status of calves born at this time. (One of the two animals born in the last 3 weeks of the calving period had a very high weaning weight, which has increased the average to 259kg. As only two animals are in this category, this average must be interpreted with care).

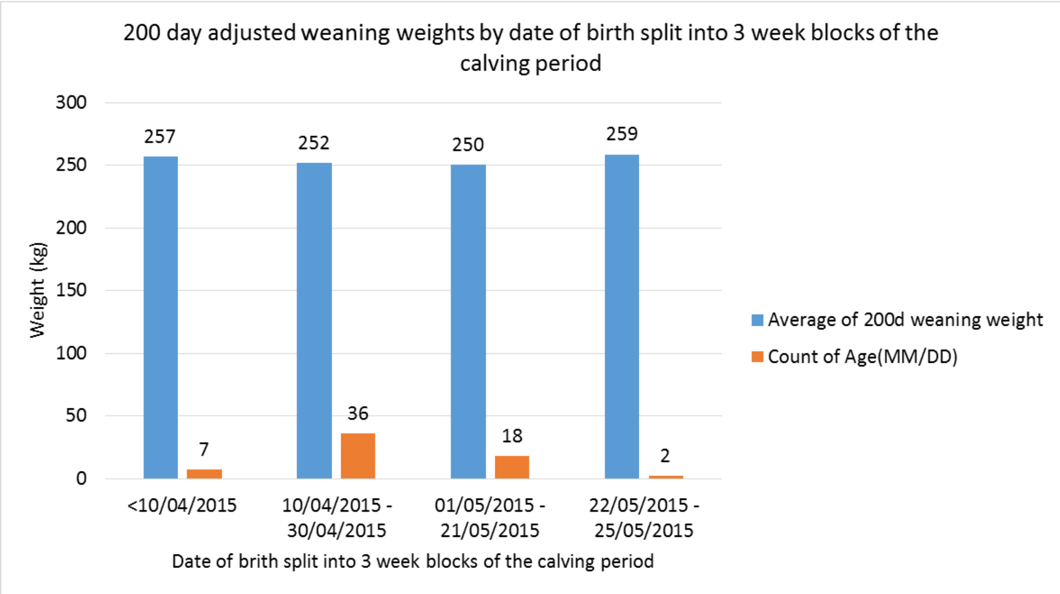
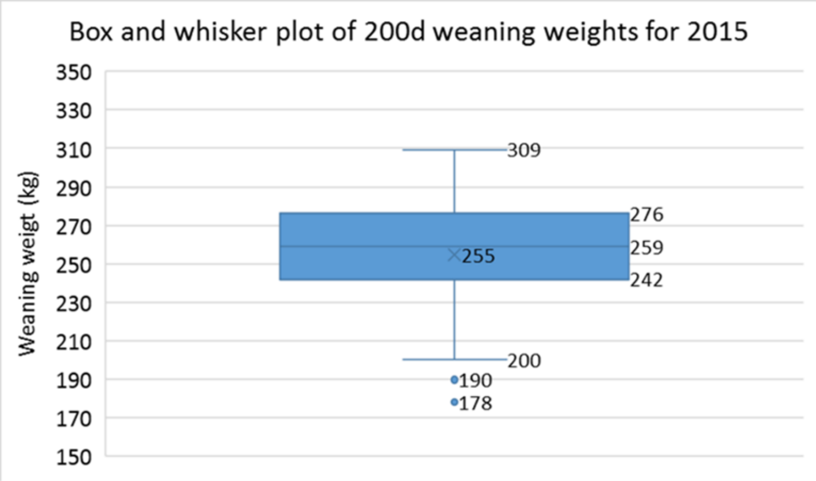


Figure 14: Example bar chart of 200 day adjusted weaning weights by date of birth in an upland suckler herd

As previously mentioned, it can often be useful to evaluate the distribution of data to get a more complete picture of herd performance. Again this can be done using a box and whisker plot as illustrated in this example (Figure 15). Here we can see that 50% of calves had 200 day weaning weights between 276kg and 242kg, but that two poor performers only achieved weights of 190kg and 178kg. With this information possible reasons for this could be investigated, and options for improving performance assessed.



KEY
Box – Middle 50% of values
Line – Median (middle value)
X – Average (mean)
Whiskers – Minimum and maximum values

Figure 15: Example box and whisker plot of 200 day adjusted weaning weights in an upland suckler herd

% animals hitting target spec

Processors and retailers are increasingly paying a premium for cattle meeting target weights and specifications, and so monitoring this aspect of herd performance is becoming increasingly important. Here we can see two suggested methods of displaying carcase classification data. The bar chart allows comparison between different years, and the grid can be used as an indicator of uniformity of carcass classifications. This is a challenging measure to set targets for, as different animals and different systems will be aiming for different target classifications. A way around this might be to record in a 'yes/no' fashion whether an animal has attained its specific target carcase class, or for software to allow different targets to be set for individuals/groups of animals. Animals hitting target weight is also becoming increasingly important, and this data could be handled and displayed in a similar way to fat classification.

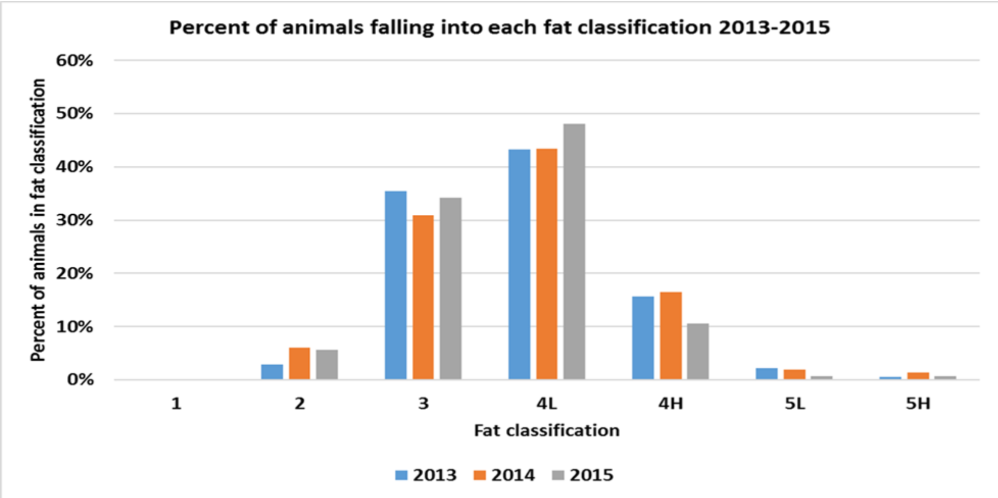


Figure 16: Example bar chart of fat classifications over several years in an intensive finishing enterprise

2015					
	1	2	3	4	5
E	0.0%	0.0%	0.0%	0.0%	0.0%
U	0.0%	0.0%	0.8%	2.4%	0.0%
R	0.0%	0.3%	12.7%	30.3%	0.0%
O	0.0%	0.0%	10.3%	43.3%	0.0%
P	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 17: Grid showing percent of animals in each carcass classification in a pasture based grower/finisher herd

Financial

Discussion during TAG meetings has highlighted an appetite for software to link financial performance indicators to physical measures, which farmers often have more immediate control over. Currently, these two important aspects of herd management appear to be challenging to link with standard herd management packages. During this project we have used statistical modelling to look at associations between physical performance indicators and a financial measure of overall enterprise success (net margin/cow bred or net margin/head of output) using the AHDB Stocktake data set, as discussed in ‘Analysis of correlations between KPIs and overall enterprise success’.

Total cost/kg output

Cost of production is frequently quoted as being an important determinant of net margin, and so relating this to a measure of output, i.e. kg produced (whether that is weaned calf or finished animal) is a good measure of efficiency. It does however require cost of production at an enterprise level, which for this study was obtained from the Stocktake database. Standing alone, financial metrics tend to be herd level aggregates, with limited data display options. In Figure 18, total costs/kg of live weight output has been plotted between 2013 and 2015, alongside net margin for these 3 years. It illustrates how as cost/kg output decreases, net margin increases.

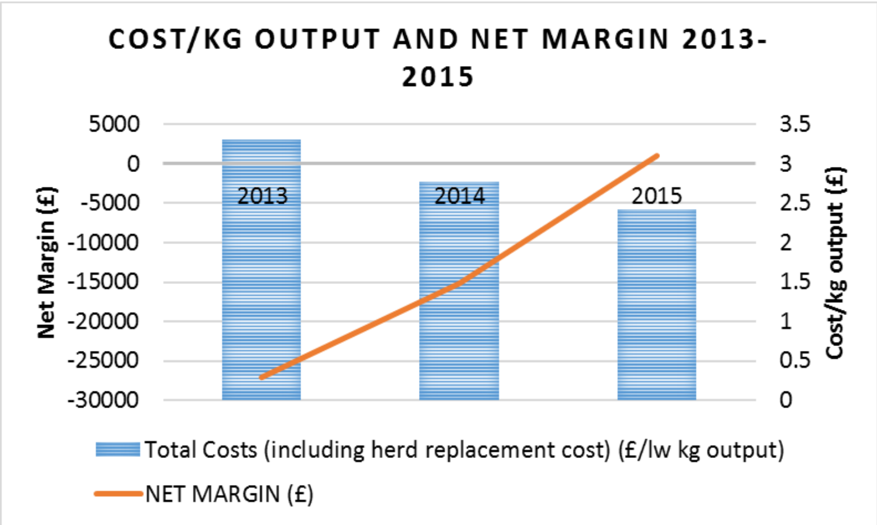


Figure 18: Example graph of cost/kg output and net margin over three years in an upland suckler herd

Total cost/head/day

Total cost/head/day was suggested by the TAG as a way of monitoring efficiency day to day, and of defining a ‘break-even’ point to help inform buying and selling decisions. Total costs were obtained from AHDB Stocktake and herd size data was calculated from movement records. These were used to calculate cost/head/day as shown in table 2, again showing decreasing cost of production over the same time period that net margin was increasing.

	2013	2014	2015
Total Costs (£)	110574.50	102266.00	89544.70
Herd size	364	373	385
Cost/head/year (£)	303.78	274.17	232.58
Cost/head/day (£)	0.83	0.75	0.64

Table 2: Cost/head/day 2013-2015 in an upland suckler herd

Health

With increasing public interest around the welfare of farmed animals, having a 'health' category of performance indicators was felt to be important by the TAG. In particular, monitoring the use of antibiotics was deemed a priority.

% cattle treated with antibiotics

This performance indicator was considered to be a useful overall indicator of the level of antibiotic use on an enterprise. It was appreciated that the type of drug used and the re-treatment rates were also important however. This stacked bar graph (Figure 19) shows the percentage of the herd treated for individual conditions by quarter, which can be useful for assessing seasonal trends. In this example treatment rates tend to increase in quarter 2, which is probably because this is a spring calving herd so that will be a high-risk time. As the bars also indicate the conditions treated, it can be seen that 'calving' does make up a large proportion of the treatment rate in quarter 2 2013 and quarter 2 2015.

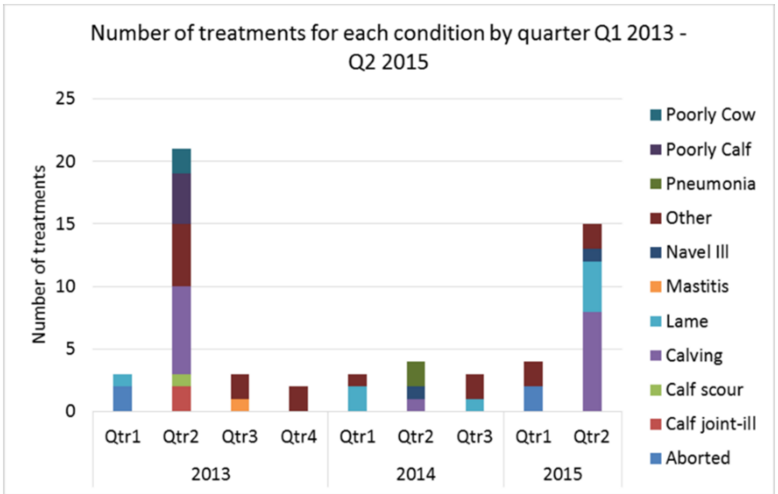


Figure 19: Example bar chart of treatment rate and condition treated by quarter for an upland suckler herd

This data could also be displayed yearly. Likewise, instead of splitting bars into condition treated, they could also be broken down by class of antibiotic used, or age of animal treated, to further 'drill down' into the data and pin-point potential areas for improvement. Although useful for monitoring seasonality of disease incidence, care needs to be taken when interpreting quarterly or monthly treatment rates; we are often used to looking at yearly treatment rates, so monthly rates will often appear low in comparison, and should be multiplied up (or added together if available for the whole year) if comparisons to yearly incidence rates are to be made.

Herd replacement rate

Herd replacement rate was fitted into the hierarchy as a KPI as it is composed of mortality and culling rates, and so is a more comprehensive performance indicator. The numerator consists of mortality rate and culling rate (plus any animals sold for breeding). Herd replacement rate in itself doesn't tell you anything about cow longevity, unless voluntary culls (i.e. exits from the herd as a result of a management decision) are distinguished from involuntary culls (i.e. deaths/culls due to loss of production). It was felt that the idea of being able to identify these different 'losses' of cattle graphically would be of benefit (although it was appreciated that the line between voluntary and involuntary culls can often be blurred). The 'cull' section of each bar could also be further broken down by reasons for culls.

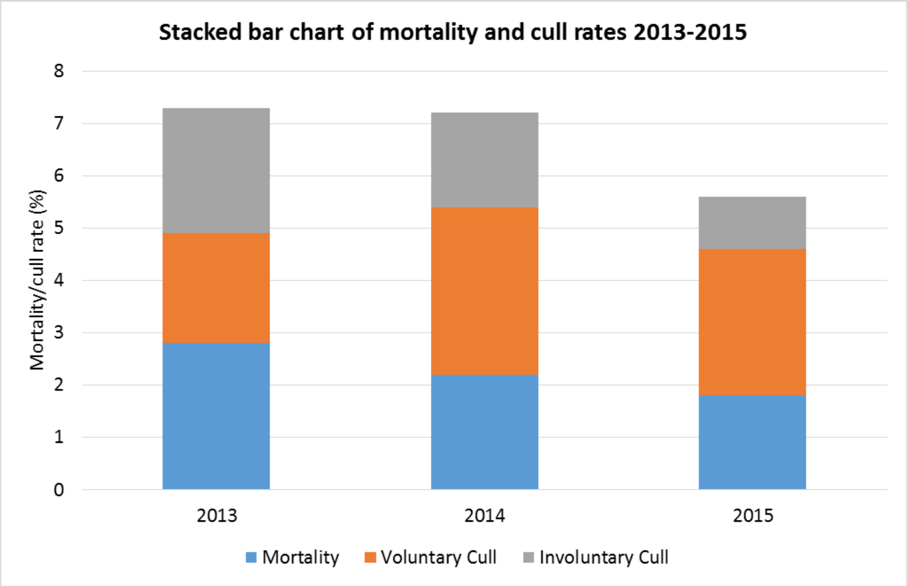


Figure 20: Example bar chart of mortality and cull rates (herd replacement rate)

In a similar way to treatment rates, mortality rates can also be broken down by month to assess seasonal trends. Contributions to overall mortality rates made by different age ranges can also be assessed. On a finishing unit it may be useful to break down mortality rates by days on farm, or by cause of death, rather than age. Care must be taken with interpretation of monthly mortality rates, in the same way as with monthly treatment rates, as comparing them to yearly rates can cause confusion.

When calculating rates a ‘herd size denominator’ is needed, i.e. the number of animals at risk of being treated/dying during the time period being evaluated. In a suckler herd this is relatively easy to calculate, as herd size is relatively stable. On a finisher or grower/finisher enterprise however cattle move on and off relatively frequently, and so herd size can be very variable. On an intensive finishing unit, some cattle may only be on the unit for a short space of time, and the total number to go through the unit is much higher than the herd size at any point in the year. In this instance using the number of cattle-years as a denominator may be more appropriate (i.e. the total number of animals on the unit each day added together and divide by 365). This denominator will take into account the total number of animals that have passed through the unit in a year, and the length of time each one was on the unit and so at risk of being treated. In the example below the average herd size, the total number of animals through the unit, and the number of cattle years, have all been used to calculate mortality rate to highlight the differences.

	Denominator		
	Average herd size	**Total number sold**	**Number cattle-years**
Population at risk size	2700	4245	3163
Mortality number	82	82	82
Mortality rate (%)	3.04	1.93	2.60

Table 3: Mortality rate calculated using three different population at risk sizes

Using regression analysis to analyse farm data

Where sufficient data was available within the datasets, inferential analysis techniques have been used. These involve statistical models which allow the data to be used to make propositions about performance in the wider beef enterprise 'population'. Regression analysis has been used to explore the relationship between a dependent (or outcome) variable and one or more independent (or predictor) variables. This allows evaluation of the degree to which each independent variable affects the dependent one, and so can be used to analyse the effect several different performance indicators have on a single overall indicator of enterprise success within that dataset. The relationship between the number of antibiotic treatments for pneumonia and DLWG was initially investigated for this farm, and this was then expanded to incorporate other predictors of DLWG. Predictors of an animal receiving an antibiotic treatment on this farm were also investigated using this method. This has allowed an individual and independent effect to be allocated to each variable, which takes into account the effects of all the other variables in the model, and illustrates how detailed data recording can provide valuable insight into how herd performance can be optimised.

Investigating the relationship between antibiotic treatments for pneumonia and DLWG using linear regression

Initially, DLWG was assessed in relation to number of antibiotic treatments for pneumonia using a bar chart as shown below. This shows that, on this farm, as number of treatments for pneumonia increase, DLWG decreases.

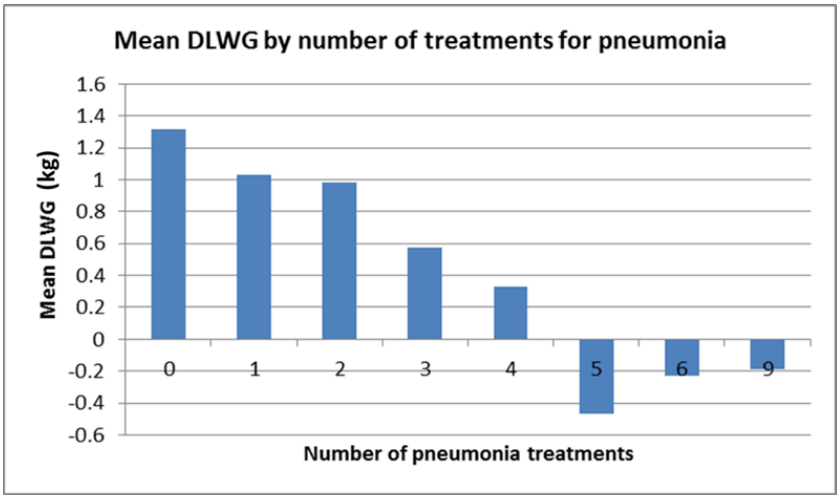


Figure 21: Bar chart of DLWG by number of treatments for pneumonia

Very few animals have large numbers of pneumonia treatments (only two animals had 9 treatments), so it is important to check the significance of the relationship. This can be done in a variety of ways, but to allow investigation of the effect of other variables on DLWG, in this instance it was done using linear regression.

Model 1 – DLWG and number of antibiotic treatments for pneumonia

As there are relatively small numbers of animals treated for pneumonia, antibiotic treatments for pneumonia were grouped into three groups 0 (0 antibiotic treatments for pneumonia), 1 (1 antibiotic treatment for pneumonia) and 2 (more than one antibiotic treatment for pneumonia).

Model term	Coefficient	Standard error	P-value
Outcome: on-farm daily liveweight gain			
Intercept	1.315	0.003	
Antibiotic treatment for pneumonia category: 0	Reference		
Antibiotic treatment for pneumonia category: 1	-0.132	0.050	<0.05
Antibiotic treatment for pneumonia category: >1	-0.310	0.035	<0.01

Table 4: Model 1 - DLWG and number of antibiotic treatments for pneumonia

The model illustrated that the predicted DLWG of an animal with no treatments for pneumonia is 1.315kg. Being treated with antibiotics once for pneumonia is associated with a loss in DLWG of 0.132kg relative to an untreated animal, whereas receiving more than one antibiotic treatment for pneumonia is associated with a loss in DLWG of 0.310kg relative to an untreated animal. Both categories of the treatment variable were significantly different to the reference (non-treated) category ($p<0.05$).

Investigating predictors of DLWG using multiple regression

There are obviously many other variables that can affect DLWG, so these were also investigated using this model. Many of these variables are likely to be correlated with each other, for example purchase price and age at purchase (i.e. older animals are likely to be more expensive). This can make it impossible to judge which of the variables is having most effect on the outcome (DLWG in this case). This is where multiple regression is useful, as it allows us to 'partition' variability in DLWG between all the variables in the model, providing an individual and independent effect for each.

This dataset allowed investigation into the following variables:

- **Purchase price** – this was calculated/kg to allow for variation in size of animal at purchase.
- **Purchase month** – initially analysis was done with months as individual categories, but groups of months were very similar to each other so were combined, in order to make the results simpler, forming 3 categories:
    - 1 = Spring (Feb/March/April)
    - 2 = Autumn (September/October/November)
    - 0 = Other (May/June/July/August/December/January)
- **Number of antibiotic treatments** – grouped in the same way as number of antibiotic treatments for pneumonia, i.e. 0, 1 and >1.
- **Source** – there are a very large number of sources (markets) so 8 categories were created, one for each of the top 7 sources (1-7) and an 'other' category (0) for everything else.
- **Age at purchase**
- **Breed** – the following breed categories were available in the data set. There were very few animals in the 'specialist' category, so this was grouped with the 'Native' category. Categories are: Native/specialist, Angus, Continental, Dairy, and Hereford.

Model 2 – Predictors of DLWG

Model term	Coefficient	Standard error	P-value
Outcome: on-farm daily liveweight gain			
Intercept	1.38	0.011	
Purchase price (£/kg, centered around mean)	0.066	0.011	<0.01
Purchase month: May/Jun/Jul/Aug/Dec/Jan	Reference		
Purchase month: Feb/Mar/Apr	0.067	0.008	<0.01
Purchase month: Sept/Oct/Nov	-0.061	0.007	<0.01
Antibiotic treatment: none	Reference		
Antibiotic treatment: one	-0.123	0.031	<0.01
Antibiotic treatment: more than one	-0.276	0.026	<0.01
Source: Other	Reference		
Source 1	0.070	0.011	<0.01
Source 2	0.040	0.010	<0.01

Source 3	-0.027	0.017	>0.05
Source 4	0.077	0.011	<0.01
Source 5	0.020	0.011	>0.05
Source 6	0.043	0.020	<0.05
Source 7	-0.007	0.019	>0.05
Age at purchase (months, centered around mean)	0.007	0.001	<0.01
Breed: Hereford	Reference		
Breed: Native/specialist	-0.106	0.019	<0.01
Breed: Angus	-0.022	0.013	>0.05
Breed: Continental	-0.082	0.011	<0.01
Breed: Dairy	-0.119	0.011	<0.01

Table 5: Model 2 - Predictors of DLWG

Purchase price/kg

The coefficient of 0.066 indicates that each £/kg increase in purchase price is associated with an increase in DLWG of 0.066kg. This is a significant association with a p-value <0.01. For example, a 400kg animal costing £600 (£1.50/kg) would be expected to grow 0.033kg/day faster than a 400kg animal costing £400 (£1/kg).

P**urchase month**

The reference category is ‘other’ (May/Jun/Jul/Aug/Dec/Jan). This model shows that animals purchased in the spring (Feb/March/April) are associated with a DLWG increase of 0.067kg compared to those purchased in either May-August or December-January. Animals purchased in the autumn however (September/October/November) are associated with a DLWG reduction of 0.061kg compared to animals purchased in either May-August or December-January. Both of these predictors have a significant association with DLWG with p-values both <0.01.

Number of antibiotic treatments

The reference category here is 0 treatments, so the model shows an association between an animal receiving 1 antibiotic treatment and a DLWG reduction of 0.123kg, and for those receiving more than one antibiotic treatment an associated DLWG reduction of 0.279kg. Again, both predictors have a significant association with DLWG with p-values both <0.01.

Source

The reference category here is ‘other’. This allows us to see how the estimated DLWG values change for each of the top 7 source farms, compared to the rest. Sources 1, 2, 4 and 6 are associated with DLWG increases of 0.077kg to 0.043kg compared to ‘other’ sources. Animals from sources 3, 5 and 7 are not associated with a significantly different DLWG compared to those from sources in the ‘other’ category. (P>0.05).

Age at purchase

The coefficient of 0.007 indicates an associated increase in DLWG of 0.007kg for every 1 month increase in the age of animal at purchase (P<0.01). Although this is significant statistically, as the DLWG increase is so small for every month increase in animal age, whether it is significant commercially is doubtful.

Breed

The reference category here is ‘Hereford’, so an animal in the ‘Native/Specialist’ category is associated with a DLWG 0.106kg lower compared to an animal in the ‘Hereford’ category. In the same way, an animal in the ‘Continental’ category is associated with a DLWG 0.082kg lower than an animal in the ‘Hereford’ category, and an animal in the ‘Dairy’ category by a DLWG 0.119kg lower. An animal in the ‘Angus’ category does not have a significantly different DLWG compared to a Hereford as the standard error in the model (the number in brackets) is not less than half of the coefficient (as illustrated in the table by a p-value of >0.05).

Effect sizes

This model showed several variables that have a statistically significant effect on DLWG. Although most of the effect sizes are relatively small, the effect of more than 1 antibiotic treatments on DLWG is considerable. The variation in DLWG explained by the whole model is 4.6%, i.e. the effects of all the variables included in the model combined account for 4.6% of the variation seen in DLWG. This is quite low, partly due to the relatively small effect sizes previously mentioned. For the variable with a larger effect size, i.e. the number of antibiotic treatments, low numbers of animals receiving an antibiotic treatment mean that although the effect on an individual’s DLWG is high, the overall effect on DLWG is small.

Investigating predictors of antibiotic treatment using multiple regression

In order to investigate which variables can be used to predict an animal receiving an antibiotic treatment for pneumonia a logistic regression model was used (a different type of multiple regression analysis which applies to binary [i.e. yes/no] outcome events). Variables investigated were:

- **Weight/age at purchase** (kg/month).
- **Purchase month** – individual months were used in this model as descriptive analysis of the data didn't reveal any appropriate categories by which to group months (as was the case when investigating predictors of DLWG).
- **Source** – these were grouped as previously.
- **Purchase price** – this was calculated per kg as previously.

Several of the variables showed no significant associations, probably because only a small number of cattle receive antibiotic treatments. All variables with no significant association were removed and the model was re-run.

Model 3 – Predictors of antibiotic treatment for pneumonia

Model term	Odds ratio	P-value
Outcome: Treatment for pneumonia		
Intercept	N/A	
Purchase price (£/kg, centred around mean)	2.042	<0.01
Purchase month: Jan	Reference	
Purchase month: Feb	1.138	>0.05
Purchase month: March	0.839	>0.05
Purchase month: April	1.556	>0.05
Purchase month: May	2.026	<0.05
Purchase month: June	1.501	>0.05
Purchase month: July	0.986	>0.05
Purchase month: August	2.014	>0.05
Purchase month: September	0.936	>0.05
Purchase month: October	0.689	>0.05
Purchase month: November	0.703	>0.05
Purchase month: December	0.108	<0.05

Table 6: Model 3 - Predictors of antibiotic treatment for pneumonia

Here the odds ratio has been calculated from the model to aid interpretation (the log-odds generated in the model are more difficult to interpret).

Purchase price (£/kg)

The odds of an animal receiving a treatment for pneumonia are 2 times greater for every additional £/kg purchase price.

Purchase month:

In this model the only months of purchase with significant associations with an animal receiving a treatment for pneumonia were December and May. Here an animal purchased in May has odds of receiving a treatment for pneumonia twice that of an animal purchased in January, whereas an animal purchased in December has odds of receiving a treatment for pneumonia 90% lower than an animal purchased in January.

Going forward, these methods will continue to be used to further investigate the relationships between multiple variables simultaneously. So far only one 'level' of data has been used when exploring the relationships, i.e. individual animals within a farm. These methods can however be extended to explore multiple levels of data, for example to incorporate different years or sources, allowing us to better understand the complex relationships between the many variables affecting an 'outcome' on farm.

Calculating KPIs from BCMS data

Due to matters beyond the control of the farmer, herd management data was not able to be collected from one of the TAG farms. Therefore, BCMS data was obtained using a consent form, and performance indicators were calculated using this. Performance indicators calculated included:

- % calving in the first 3/6/9 weeks of the calving period (no predicted start of calving date can be calculated from BCMS data alone).
- Calving interval – although not calculated for the other TAG farms, this performance indicator may be useful for herds that don't block calve.
- Age at first calving.
- Calves/cow life year – this performance indicator is a measure of fertility and longevity.
- Mortality rates.

Use of BCMS data works best for closed herds. When calculating age at first calving, the data only contains those calvings that occur on that holding, i.e. if a freshly calved heifer is brought on, her first recorded calving will be her second calving. To avoid this, only home bred animals should be used when calculating age at first calving. Mortality rates can be calculated, however herd sizes for each year are required which are complicated to calculate from BCMS data retrospectively. Current herd size is easier to calculate, so if herd size is relatively constant this could be used to calculate rates for previous years.

BCMS data is available for all farms, with no data collection being required by the farmer other than what is statutory. This demonstrates that these metrics can be calculated for every farm, and may be a way of introducing benchmarking to farms that don't currently performance record by providing an 'entry-level' set of performance indicators. BCMS data is provided in excel in a format that allows easy analysis. Performance indicators that can be calculated from BCMS data are restricted mainly to those relating to fertility, no weight, financial, carcass or treatment data is available. However, this data could be added, allowing a farmer to build on what is recorded and monitored as required.

Conclusions

Analysis of data sets provided by farmers in the TAG has allowed investigation of various data presentation methods. In addition, several points relevant to how data is input and stored in herd management software were raised, for example the importance of standardised data input was highlighted. Ways of further analysing data were investigated, for example investigating data distributions, and analysis by month/age group etc., allowing the data to be used more effectively for decision making. Further statistical techniques were then used to investigate the effect of multiple variables on an outcome (e.g. DLWG) simultaneously. This allows for some of the many confounding variables contributing to an outcome on farm to be accounted for.

Analysis of correlations between KPIs and overall enterprise success

Through discussion with the TAG, a definition of enterprise success of net margin/cow bred in suckler herds and net margin/head of output in grower or finisher herds was decided. In order to investigate correlations between performance indicators in the toolkit and overall enterprise success (using these definitions), data from the AHDB Stocktake database was obtained. This database allows producers to record and monitor both their financial and physical performance, and to benchmark themselves against similar farms. Data is collected by AHDB staff to ensure standardised input, but the farmer can view the data and generate reports. Economic margins for individual enterprises can be analysed, as opposed to whole farm margins, which is of great benefit in mixed enterprise farms. Margins after cash costs only, and on a full economic basis, can also be analysed which allows factors such as depreciation to be taken into account. In addition to providing individual farm information, the data is used to produce a reference document for the beef industry as a whole. Recently the data has also been used to draw international comparisons with countries that are competing with the UK in the global beef market. International comparisons are provided by 'agri benchmark', the international comparison network (www.agribenchmark.org). 'Typical' virtual farms from up to 30 member countries are used along with an internationally standardised method of analysis to benchmark the farms.

Stocktake data analysis – Suckler data

Analysis of correlations between performance indicators and overall enterprise performance was carried out using data from 56 suckler farms that recorded data in 2013, 2014 and 2015. Data from the three years was combined and categories relevant to calculating performance indicators were selected. Net margin/cow bred was used as an indicator of overall enterprise performance. A histogram of net margin/cow bred was produced in order to identify outlier data.

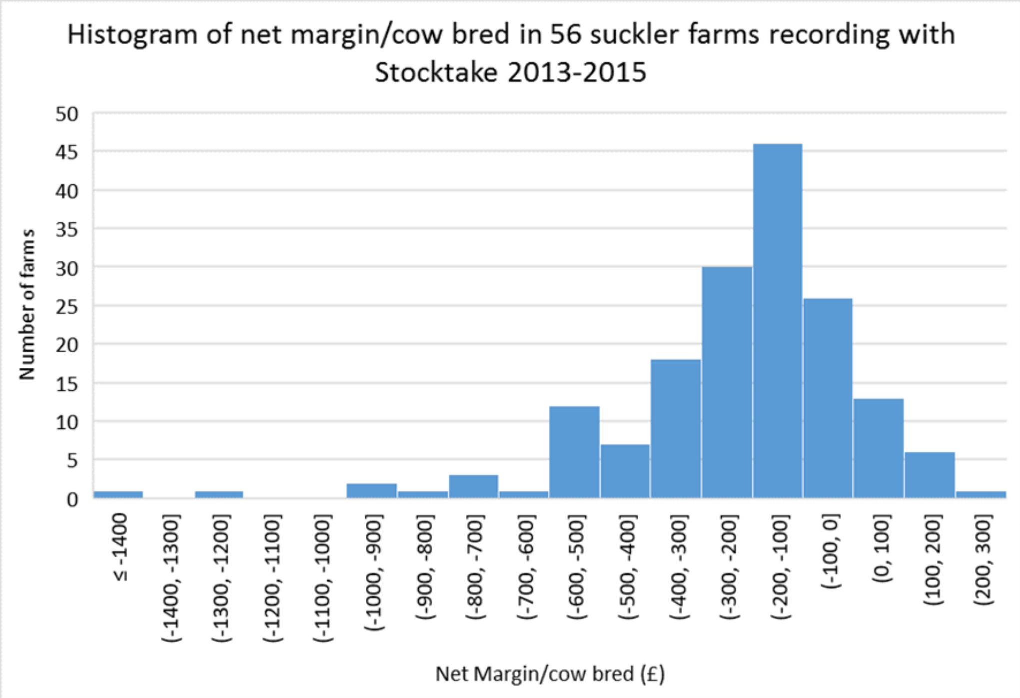


Figure 22: Histogram of net margin/cow bred for suckler Stocktake data

The three lowest net margins across the three years were all from the same farm, so this farm was removed from the dataset.

Where data was available, the KPIs and performance indicators from the toolkit were correlated with overall performance. Scatter plots (for continuous variables such as percent calving in the first 3 weeks) and bar charts (for categorical variables such as age at first calving) were used to investigate the relationship between net margin/cow bred and each performance indicator in turn. Where appropriate herds were categorised by calving pattern, for example when correlating percent calving in the first 3 weeks with net margin/cow bred. P-values were calculated to assess the statistical significance of the relationship using ANOVA. The results are summarised in table 7, with r^2 values indicating the proportion of variance (1 = all the variance) of net margin/cow bred explained by each performance indicator (continuous variables only).

Category	Performance Indicator	Significant relationship with net margin/cow bred?	Proportion of variation of net margin/cow bred explained (r^2)
Fertility	% calving in the first 3 weeks (year-round calving herds excluded and farms split into spring, autumn and multi-block calvers)	No	0.00479
	Age at first calving (farm policy – not actual age at first calving)	Yes (P<0.05)	N/A
	Calving period (year-round calving herds excluded)	No	9.84 x 10-5
	Calves weaned/100 cows bred	Yes (P<0.001)	0.070
	% scanned in calf	No	0.022
	% calves born alive	Yes (P<0.01)	0.059
Growth	Average 200d weaning weight	Yes (P<0.01)	0.044
	DLWG to weaning	Yes (P<0.05)	0.025
	200d weaning weight/forage ha	Yes (P<0.001)	0.113
	Creep feed fed/kg weaned	Yes (P<0.05)	0.027
Financial	Total cost/kg output (liveweight)	Yes (P<0.001)	0.814
	Total gross output (including herd replacement cost)	Yes (P<0.01)	0.0407
	Fixed costs/cow bred	Yes (P<0.001)	0.611
	Fixed costs as a % of total costs	Yes (P<0.05)	0.0363
	Total labour cost/cow bred	Yes (P<0.001)	0.347
	Variable costs/cow bred	No	0.00877
	Variable costs as a % of total costs	Yes (P<0.001)	0.0695
	Feed and forage cost/cow bred	No	0.00557
	Pre-weaning mortality rate	Yes (P<0.01)	0.0543
Health	Cow mortality rate	Yes (P<0.01)	0.0442
	Replacement rate	No	0.00107

Table 7: Summary of correlations between net margin/cow bred and performance indicators in the Stocktake database

Interestingly, few of the fertility performance indicators appear to be significantly correlated with net margin/cow bred in this dataset. This could be due to the relatively small sample size, particularly in categories where year-round calving herds were excluded, such as calving period and % calving in the first 3 weeks. It could also be related to inaccuracies in how the data is recorded, and the high degree of variability in fertility performance. Calves weaned/100 cows bred was strongly significantly associated with net margin/cow bred. All performance indicators in the growth category were significantly associated with net margin/cow bred, with 200d weaning weight/forage ha showing the strongest significance. In the financial category, all performance indicators were significantly associated with net margin/cow bred apart from variable costs/cow bred and feed and forage cost/cow bred. We would expect to see higher levels of significant correlation in the financial category as we are correlating two financial performance indicators, rather than correlating a physical with a financial indicator. These financial performance indicators will inherently be a component of net margin, and so are more likely to be correlated significantly. In the health category, pre-weaning mortality rate and cow mortality rate were significantly associated with net margin/cow bred.

In the fertility category, calves weaned/100 cows bred explains the most variation in net margin/cow bred (as well as being the most statistically significant). % calving in the first 3 weeks and calving period explain the least variation in net margin/cow bred, but this could be due to the factors previously discussed. In the growth category, 200d weaning weight/forage ha had the highest r^2 value (so explains the most variation in net margin/cow bred). In the financial category, total costs/kg output explains the most variation in net margin/cow bred. Again this is due to it being a component of net margin. Fixed costs/cow bred also explains over 60% of net margin/cow bred in this dataset. Variable costs/cow bred is not significantly related to net margin/cow bred, and explains less variation in it (although expressing variable costs as a % of total costs increases its r^2 value). In the health category, pre-weaning mortality rate explained the most variation in net margin/cow bred, closely followed by cow mortality rate.

Multiple regression of the Stocktake suckler dataset

To explore relationships between multiple variables (performance indicators), and to take into account that data has been collected across multiple years, multiple regression analysis was used, as described previously. This allows investigation of the relationship between a dependent (or outcome) variable and one or more independent (or predictor) variables, allowing evaluation of the degree to which each independent variable is associated with the dependent one. Here it has been used to analyse the effect several different performance indicators have on an overall indicator of enterprise success (i.e. net margin/cow bred) simultaneously.

Separate models were created for financial variables and physical variables in order to minimise multiple predictors in a model representing the same aspect of performance. The performance indicators used previously were added to each model, and those that were not significantly associated with the outcome were removed. The distribution of each variable retained in the final model was evaluated and outliers were removed where they had substantial influence on results. Variables were then added again to the model one by one to check for significance, and any that showed significant associations with the outcome variable were retained. In the suckler physical performance indicators model (Model 4), 200d weaning weight/forage hectare was found to correlate with many of the other variables affecting their significance (possibly due to it being quite a comprehensive measure incorporating components of other performance indicators in the model), and was only available for 2014 onwards. It was therefore removed from the model and stocking rate was added as this is a more specific performance indicator covering a similar aspect of performance. Random effect was used to represent herd in order to account for the fact that data from different years from the same herd is more likely to be similar than data from different years and different herds.

Model 4 – Physical predictors of net margin/cow bred

Model term	Coefficient	Standard error	P-value
Outcome: Net margin/cow bred			
Intercept	-287.296	38.215	
Year: 2013	Reference		
Year: 2014	75.001	30.833	<0.05
Year: 2015	110.377	30.672	<0.01
Scanning percentage: 0%	16.721	32.511	>0.05
Scanning percentage: 1-90%	-125.024	39.613	<0.01
Scanning percentage:>90%	Reference		
Cow:Bull ratio (centred around mean)	-2.515	0.926	<0.05
Pre-weaning deaths/100 cows or heifers put to bull (centred around mean)	-17.297	4.660	<0.01
DLWG to weaning (centred around mean)	188.571	85.153	<0.05
Age at first calving: 2 years	Reference		
Age at first calving: 2.5 years	-88.061	30.074	<0.05
Age at first calving: 3 years	-40.114	46.003	>0.05
Cow size: Small	186.646	89.669	<0.05
Cow size: Medium	98.071	32.268	<0.01
Cow size: Large	Reference		
Stocking rate (LU/ha)	57.729	15.684	<0.01

Table 8: Model 4 – Physical predictors of net margin/cow bred

Year

Year was added to the model as a predictor variable to take into account variations between years (for example in market prices). Both 2014 and 2015 were associated with significantly higher net margin/cow bred, with 2014 being associated with a net margin/cow bred of £75.00 greater than 2013 (P<0.05) , and 2015 being associated with a net margin/cow bred of £110.38 greater than 2013 (P<0.01).

Scanning percentage

A scanning percentage of 0% (89 records) was taken to mean that the enterprise didn't scan for pregnancy diagnosis, and so was categorised separately. Net margin/cow bred in this category was not significantly different to net margin/cow bred in the reference category (scanning percentage >90%) (45 records) (P>0.05). Herds that had a scanning percentage of 1-90% (27 records) however, were significantly associated with a net margin/cow bred decrease of £125.02 compared to enterprises with a scanning percentage of >90% (P<0.01).

Cow:Bull ratio

The coefficient of -2.515 for this variable indicates that each cow/heifer increase per bull (i.e. increasing from 25 cows/bull to 26 cows/bull) is associated with a net margin/cow bred reduction of £2.52 (P<0.05). This doesn't take into account however that some herds may use AI (to varying extents), which will affect their cow:bull ratio.

Pre-weaning deaths/100 cows or heifers bred

This measure of pre-weaning mortality shows an association between each calf death/100 cows or heifers bred and a net margin/cow bred reduction of £17.30 (P<0.01).

DLWG to weaning

A DLWG to weaning increase of 0.1kg is associated with an increase in net margin/cow bred of £18.86 (P<0.05).

Age at first calving

In this model, herds with a target age at first calving of 2.5 years are associated with a net margin/cow bred decrease of £88.06 compared with herds aiming to calve heifers at 2 years (P<0.05). Herds aiming to calve heifers at 3 years were not associated with a significantly different net margin/cow bred than those with a target age at first calving of 2 years (P>0.05).

Cow size

Cow size had a significant association with net margin/cow bred in this model (although there are very small numbers of herds in the ‘small’ category). Compared to herds with ‘large’ cows, herds with ‘small’ cows were associated with a net margin/cow bred increase of £186.65 (P<0.05), whereas herds with ‘medium’ cows were associated with a net margin/cow bed increase of £98.07 (P<0.01). In this dataset Large cows were defined as >650kg liveweight, medium as 500-650kg and small as <500kg.

Stocking rate

In this model, increasing stocking rate by one LU/ha is associated with an increase in net margin/cow bred of £57.73.

Financial performance indicators were analysed using the same model building process as described for the physical indicators, with net margin/cow bred as the outcome variable. A number of the financial variables were aggregates or totals of other variables (for example, totals of fixed and variable costs), and were therefore highly or completely correlated with each other. Including these aggregate variables in the same model as their components would be inappropriate, so only variables at the lowest level (such that no variable analysed was calculated directly from any other variable) were analysed, with those showing significant associations retained in the model. Variables included in the analysis were:

- Total feed and forage costs for the suckler herd/cow bred
- Total labour cost/cow bred (paid and unpaid, allocated to the suckler herd)
- Suckler herd gross output/cow bred (excluding replacement costs)
- Veterinary and medicine costs for the suckler herd/cow bred
- Bedding costs for the suckler herd/cow bred
- Contracting and machine hire costs for the suckler herd/cow bred
- Machinery repairs and spares costs for the suckler herd/cow bred
- Fuel costs allocated to the suckler herd/cow bred

- Property maintenance and water costs for the suckler herd/cow bred
- Depreciation (machinery and property) for the suckler herd/cow bred
- Suckler herd replacement cost/cow bred
- Imputed suckler herd net field rent/cow bred
- Imputed cost of finance allocated to the suckler herd/cow bred

These were individually correlated with net margin/cow bred using scatter plots (Figure 23), and P-values and r^2 values were calculated to assess significance and proportion of variation in net margin/cow bred explained by each variable (table 9).

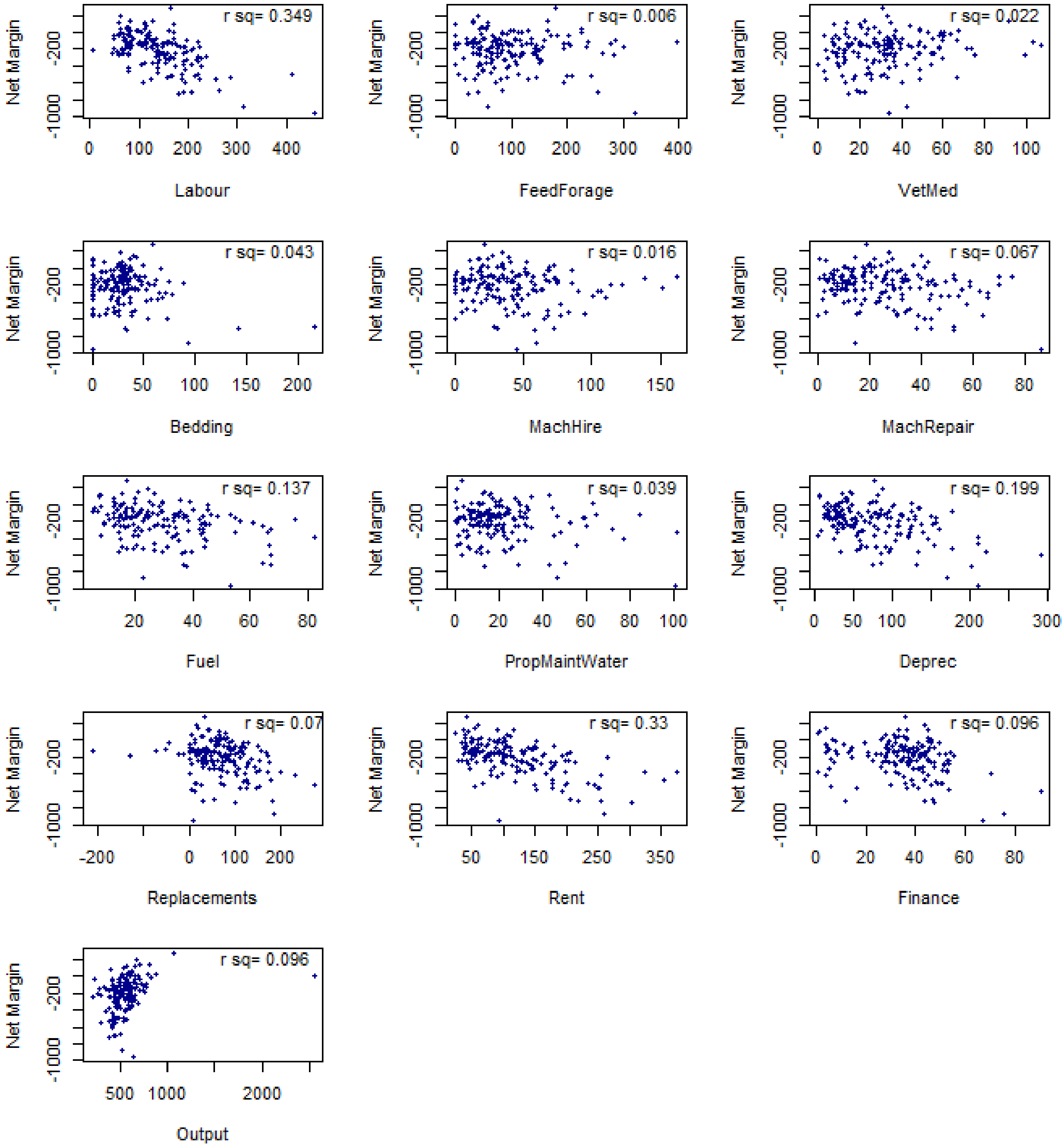


Figure 23: Scatter plots of correlations between net margin/cow bred and financial performance indicators in the Stocktake database.

Performance Indicator	*Significant relationship with net margin/cow bred?*	*Proportion of variation of net margin/cow bred explained (r^2)*
Total feed and forage cost/cow bred	No	0.00557
Total labour cost/cow bred	Yes (P<0.001)	0.347
Suckler herd gross output/cow bred (excluding replacement costs)	Yes (P<0.001)	0.0956
Veterinary and medicine costs for the suckler herd/cow bred	No	0.0221
Bedding costs for the suckler herd/cow bred	Yes (P<0.01)	0.0429
Contracting and machine hire costs for the suckler herd/cow bred	No	0.0164
Machinery repairs and spares costs for the suckler herd/cow bred	Yes (P<0.001)	0.0668
Fuel costs allocated to the suckler herd/cow bred	Yes (P<0.001)	0.137
Property maintenance and water costs for the suckler herd/cow bred	Yes (P<0.05)	0.0388
Depreciation (machinery and property) for the suckler herd/cow bred	Yes (P<0.001)	0.199
Suckler herd replacement cost/cow bred	Yes (P<0.001)	0.0769
Imputed suckler herd net field rent/cow bred	Yes (P<0.001)	0.330
Imputed cost of finance allocated to the suckler herd/cow bred	Yes (P<0.001)	0.0956

Table 9: Summary of correlations between net margin/cow bred and financial performance indicators in the Stocktake database

Model 5 – Financial predictors of net margin/cow bred in the Stocktake database

Model term	**Coefficient**	**Standard error**	**P-value**
Outcome: Net margin/cow bred			
Intercept	-223.462	9.088	
Year: 2013	Reference		
Year: 2014	23.339	12.833	>0.05
Year: 2015	47.000	13.090	<0.01
Fuel cost allocated to the suckler herd/cow bred (centred around mean)	-1.788	0.414	<0.01
Bedding costs for the suckler herd/cow bred (centred around mean)	-1.470	0.297	<0.01
Veterinary and medicine costs for the suckler herd/cow bred (centred around mean)	-1.456	0.370	<0.01
Contracting and machine hire for the suckler herd/cow bred (centred around mean)	-1.243	0.196	<0.01
Total labour cost/cow bred (allocated to the suckler herd, including paid and unpaid labour) (centred around mean)	-1.177	0.097	<0.01

Suckler herd replacement costs/cow bred (centred around mean)	-0.971	0.098	<0.01
Depreciation (machinery and property allocated to the suckler herd)/cow bred (centred around mean)	-0.960	0.119	<0.01
Imputed suckler herd net field rent/cow bred (centred around mean)	-0.802	0.092	<0.01
Machinery repairs and spares for the suckler herd/cow bred (centred around mean)	-0.800	0.319	<0.05
Suckler herd gross output (excluding replacement costs)/cow bred (centred around mean)	0.726	0.044	<0.01

Table 10: Model 5 – Financial predictors of net margin/cow bred in the Stocktake database

Year

Again, this was added to the model as a predictor variable to take into account variation between years. Compared to 2013, net margin/cow bred was associated with an increase of £47.00 in 2015 ($P<0.01$), although the difference between 2013 and 2014 was not significant ($P>0.05$).

Fuel cost allocated to the suckler herd/cow bred

Each pound decrease in fuel cost allocated to the suckler herd/cow bred is associated with an increase in net margin/cow bred of £1.79.

Bedding costs for the suckler herd/cow bred

Each pound decrease in bedding costs for the suckler herd/cow bred is associated with an increase in net margin/cow bred of £1.47 ($P<0.01$).

Veterinary and medicine costs for the suckler herd/cow bred

Each pound decrease in veterinary and medicine costs/cow bred is associated with an increase in net margin of £1.46 ($P<0.01$).

Contracting and machine hire for the suckler herd/cow bred

Each pound decrease in contracting and machine hire costs for the suckler herd/cow bred is associated with an increase in net margin/cow bred of £1.24 ($P<0.01$).

Total labour cost/cow bred

Each pound decrease in total labour costs/cow bred is associated with an increase in net margin/cow bred of £1.18 ($P<0.01$).

Suckler herd replacement cost/cow bred

Each pound decrease in replacement costs for the suckler herd/cow bred is associated with an increase in net margin/cow bred of 97p ($P<0.01$).

Depreciation (machinery and property allocated to the suckler herd)/cow bred

Each pound decrease in depreciation/cow bred is associated with an increase in net margin/cow bred of 96p ($P<0.01$).

Imputed suckler herd net field rent/cow bred

Each pound decrease in imputed net field rent/cow bred is associated with an increase in net margin/cow bred of 80p ($P<0.01$).

Machinery repairs and spares for the suckler herd/cow bred

Each pound decrease in machinery repairs and spares cost for the suckler herd/cow bred is associated with an increase in net margin/cow bred of 80p ($P<0.05$).

Suckler herd gross output (excluding replacement costs)/cow bred

Each pound increase in suckler herd gross output/cow bred is associated with an increase in net margin/cow bred of 73p.

The fact that so many financial variables are significantly associated with net margin/cow bred (a financial outcome) is to be expected, as they are all essentially components of the outcome. The model allows these associations to be quantified, whilst the r^2 values illustrate the proportion of variation in net margin/cow bred accounted for by each cost component.

Stocktake data analysis – Grower/finisher data

Analysis of correlations between performance indicators and overall enterprise performance was carried out using data from 36 beef farms that recorded data in 2013, 2014 and 2015. Data from the three years was combined and categories relevant to calculating performance indicators were selected. Net margin/head of output was used as an indicator of overall performance. A histogram of Net margin/head output was produced in order to identify outlier data.

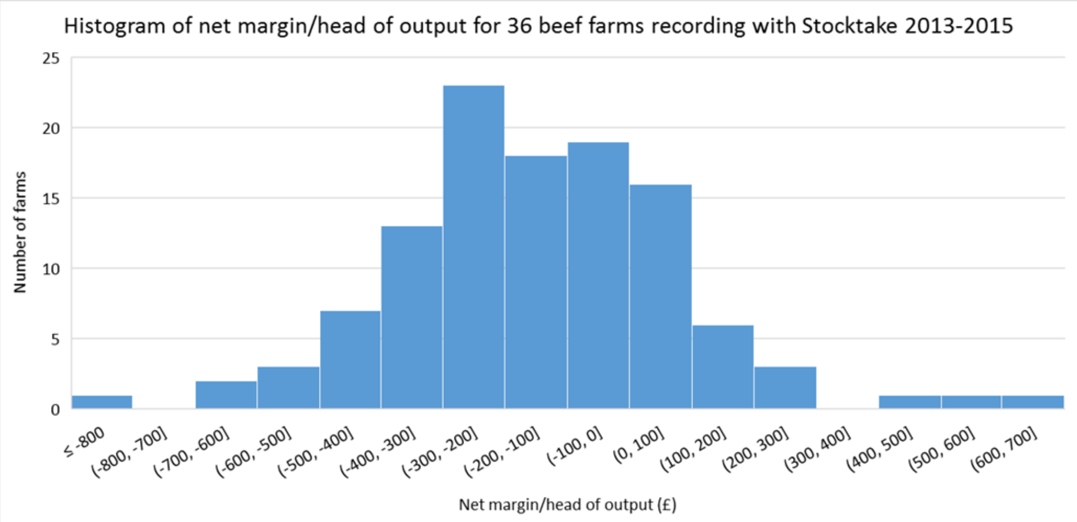


Figure 24: Histogram of net margin/head of output for grower/finisher Stocktake data

Data distribution was more symmetrical than in the suckler dataset, and no extreme outliers were identified that could have the potential to have undue influence on the result. However, 2 farms had very low numbers of animals or head of output over the three years, so were both removed.

Where data was available, the KPIs and performance indicators from the toolkit applicable to grower/finisher enterprises were correlated with overall performance (net margin/head of output) one by one. Scatter plots were used to investigate relationships between net margin/head of output and other variables as previously. P-values and r^2 values were then calculated as previously to assess the statistical significance of the relationship, and the amount of variation in net margin explained by each performance indicator. The results are summarised in the table below.

Category	***Performance indicator***	***Significant relationship with net margin/head of output?***	***Proportion of variation of net margin/cow bred explained (r^2)***
Growth	DLWG	No	0.0112
	Average weight gain	No	0.00120
	Kg produced/forage ha	No	0.000256
	Average age at slaughter	No	0.0146
Financial	Total cost/kg output (liveweight)	Yes (P<0.001)	0.345
	Beef enterprise gross output	No	0.0200
	Fixed costs/head of output	Yes (P<0.001)	0.127

	Fixed costs as a % of total costs	No	0.0158
	Labour cost/head of output	Yes (P<0.001)	0.132
	Variable costs/head of output	Yes (P<0.001)	0.101
	Variable costs as a % of total costs	No	0.00641
	Feed and forage costs/head of output	Yes (P<0.05)	0.0585
Health	Mortality rate	No	0.00326

Table 11: Summary of correlations between net margin/head of output and performance indicators in the Stocktake database

In this dataset none of the physical performance indicators (growth or health) were significantly correlated with net margin/head of output. Of the financial indicators, both labour and feed costs/head of output were significantly correlated with net margin/head of output, with labour costs accounting for 13% of the variation in net margin and feed costs just under 6%. Variable and fixed costs showed a significant relationship with net margin/head of output when expressed per head of output (but not when expressed as a % of total costs). Fixed costs/head of output account for just under 13% of the variation in net margin/head of output, and variable costs just over 10%. Total costs/kg output (liveweight) was also significantly correlated with net margin/head of output, accounting for 34.5% of variation seen in net margin/head of output.

Multiple regression of the Stocktake grower/finisher dataset

As previously, multiple regression was used to explore relationships between net margin/head of output and multiple variables simultaneously. Models were built as for the suckler herd dataset, again with separate models for physical and financial variables. However, no physical performance indicators showed significant associations with net margin/head of output. Again, more specific lower level financial variables were added to the model in place of the more comprehensive high level ones, these were:

- Total feed and forage costs for the beef enterprise/head of output
- Total labour cost/head of output (paid and unpaid, allocated to the beef enterprise)
- Beef enterprise gross output/head of output
- Veterinary and medicine costs for the beef enterprise/head of output

- Bedding costs for the beef enterprise/head of output
- Total cost of beef cattle purchases and transfers/head of output
- Machinery repairs and spares for the beef enterprise/head of output
- Contracting and machine hire costs for the beef enterprise/head of output
- Fuel for the beef enterprise/head of output
- Property maintenance and water costs for the beef enterprise/head of output
- Depreciation (machinery and property) for the beef enterprise/head of output
- Imputed costs of finance allocated to the beef enterprise/head of output
- Total machinery and power costs (excluding depreciation) for the beef enterprise/head of output
- Imputed beef enterprise net field rent/head of output

These were individually correlated with net margin/head of output using scatter plots as previously (Figure 25), and P-values and r^2 values were calculated to assess significance and proportion of variation in net margin/cow bred explained by each variable (table 12).

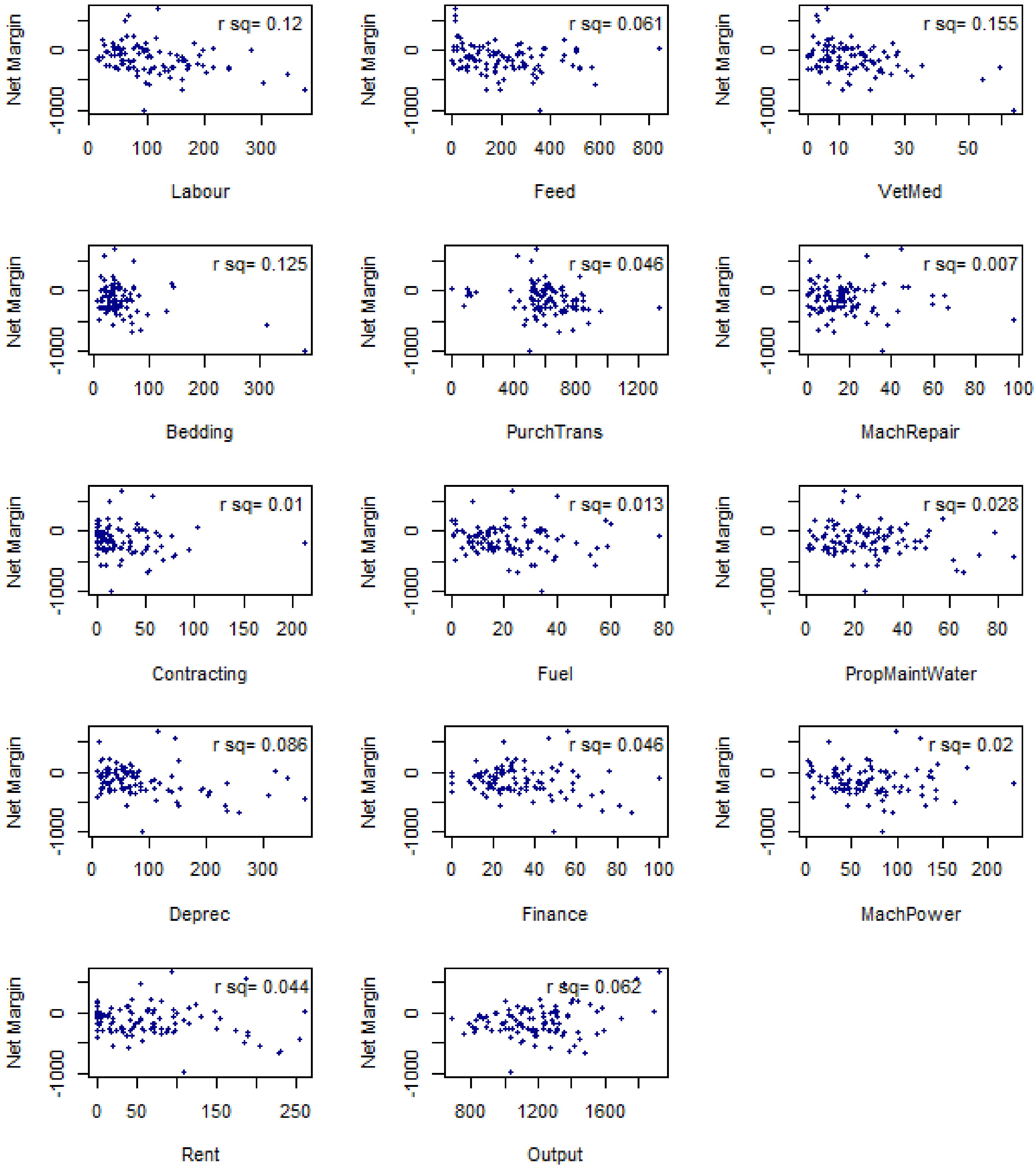


Figure 25: Scatter plots of correlations between net margin/head of output and financial performance indicators for the grower/finisher herd

Performance Indicator	***Significant relationship with net margin/head of output?***	***Proportion of variation of net margin/head of output explained (r^2)***
Total feed and forage cost/head of output	Yes (P<0.05)	0.0613
Total labour cost/head of output	Yes (P<0.001)	0.120
Beef enterprise gross output/head of output	Yes (P<0.05)	0.0619
Veterinary and medicine costs for the beef enterprise/head of output	Yes(P<0.001)	0.155
Bedding costs for the beef enterprise/head of output	Yes(P<0.001)	0.125
Contracting and machine hire costs for the beef enterprise/head of output	No	0.00961
Machinery repairs and spares costs for the beef enterprise/head of output	No	0.00744
Fuel costs allocated to the suckler herd/cow bred	No	0.0126
Property maintenance and water costs for the beef enterprise/head of output	No	0.0282
Depreciation (machinery and property) for the beef enterprise/head of output	Yes(P<0.01)	0.0860
Imputed cost of finance allocated to the beef enterprise/head of output	Yes (P<0.05)	0.0465
Total machinery and power costs (excluding depreciation) for the beef enterprise/head of output	No	0.0201
Imputed beef enterprise net field rent/head of output	Yes (P<0.05)	0.0443

Table 12: Summary of correlations between net margin/head of output and financial performance indicators in the Stocktake database

Model 6 - Stocktake beef herd physical and financial performance indicators.

Model term	**Coefficient**	**Standard error**	**P-value**
Outcome variable: Net margin/head of output			
Intercept	-140.803	5.917	
Year: 2013	Reference		
Year: 2014	2.372	8.002	P>0.05
Year: 2015	4.740	8.127	P>0.05
Depreciation (machinery and property) for the beef enterprise/head of output (centred around mean)	-1.337	0.069	P<0.01
Imputed costs of finance allocated to the beef enterprise/head of output (centred around mean)	-1.132	0.291	P<0.01
Total labour cost/head of output (paid and unpaid, allocated to the beef enterprise) (centred around mean)	-1.106	0.054	P<0.01
Contracting and machine hire for the beef enterprise/head of output (centred around mean)	-0.944	0.111	P<0.01
Feed and forage cost for the beef enterprise/head of output (centred around mean)	-0.938	0.026	P<0.01

Imputed beef enterprise net field rent/head of output (centred around mean)	-0.936	0.092	P<0.01
Total cost of beef cattle purchases and transfers/head of output (centred around mean)	-0.926	0.021	P<0.01
Machinery repairs and spares for the beef enterprise/head of output (centred around mean)	-0.909	0.221	P<0.01
Beef enterprise gross output/head of output (centred around mean)	0.901	0.019	P<0.01
Property maintenance and water costs for the beef enterprise/head of output (centred around mean)	-0.753	0.189	P<0.01
Bedding costs for the beef enterprise/head of output (centred around mean)	-0.662	0.125	P<0.01

Table 13: Model 6 - Stocktake grower/finisher herd financial performance indicators

Year

Neither 2014 nor 2015 were associated with a significant difference in net margin/head of output compared to 2013.

Depreciation (machinery and property) for the beef enterprise/head of output

Each pound decrease in depreciation/head of output is associated with an increase in net margin/head of output of £1.34.

Imputed costs of finance allocated to the beef enterprise/head of output

Each pound decrease in imputed costs of finance/head of output is associated with an increase in net margin/head of output of £1.13.

Total labour cost/head of output

Cost of paid and unpaid labour allocated to the beef herd was analysed. Each pound decrease in labour cost (paid and unpaid)/head of output is associated with an increase in net margin/head of output of £1.11.

Contracting and machine hire for the beef enterprise/head of output

Each pound decrease in contracting and machine hire cost for the beef enterprise/head of output is associated with an increase in net margin/head of output of 94p.

Feed and forage cost for the beef enterprise/head of output

Each pound decrease in feed and forage cost for the beef enterprise/head of output is associated with an increase in net margin/head of output of 94p.

Imputed beef enterprise net field rent/head of output

Each pound decrease in imputed net field rent/head of output is associated with an increase in net margin/head of output of 94p.

Total cost of beef cattle purchases and transfers/head of output

Each pound decrease in cost of beef cattle purchases and transfers/head of output is associated with an increase in net margin/head of output of 93p.

Machinery repairs and spares for the beef enterprise/head of output

Each pound decrease in machinery repairs and spares costs for the beef enterprise is associated with an increase in net margin/head of output of 91p.

Beef enterprise gross output/head of output

Each pound increase in gross output/head of output is associated with an increase in net margin/head of output of 90p.

Property maintenance and water costs for the beef enterprise/head of output

Each pound decrease in property maintenance and water costs/head of output is associated with an increase in net margin/head of output of 75p.

Bedding costs for the beef enterprise/head of output

Each pound decrease in bedding costs/head of output is associated with an increase in net margin/head of output of 66p.

Again, the fact that so many financial variables are significantly associated with net margin/head of output (a financial outcome) is to be expected, as they are all essentially components of the outcome. Only veterinary and medicine costs/head of output, fuel costs/head of output, and total machinery and power costs /head of output were not significantly associated with net margin/head of output. Again, the model allows these associations to be quantified, whilst the r^2 values illustrate the proportion of variation in net margin/cow bred accounted for by each cost component.

Summary

In the suckler herd dataset several physical and financial performance indicators showed statistically significant associations with net margin/cow bred. These included scanning percentage, cow:bull ratio, pre-weaning deaths/100 cows or heifers put to the bull, DLWG to weaning, age at first calving, cow size and stocking rate. In the grower/finisher dataset, significant associations were identified only between financial performance indicators and net margin/head of output. Of the financial performance indicators, several showed significant associations in both datasets, for example total labour costs and depreciation. Some only showed significant associations in one of the datasets, for example veterinary and medicine costs and fuel costs were significantly associated with net margin/cow bred in the suckler dataset only, whereas the imputed cost of finance and feed and forage costs were only significantly associated with net margin/head of output in the grower/finisher dataset. These comparisons are summarised in table 14.

Performance indicator	Suckler	Grower/finisher
	Associated increase in net margin for each unit increase in performance indicator (£)	
Fuel cost	-1.788 (P<0.01)	
Bedding cost	-1.470 (P<0.01)	-0.662 (P<0.01)
Veterinary and medicine cost	-1.456 (P<0.01)	
Contracting and machine hire	-1.243 (P<0.01)	-0.944 (P<0.01)
Total labour cost	-1.177 (P<0.01)	-1.106 (P<0.01)
Replacement cost	-0.971 (P<0.01)	
Depreciation (machinery and property)	-0.960 (P<0.01)	-1.337 (P<0.01)
Imputed net field rent	-0.802 (P<0.01)	-0.936 (P<0.01)
Machinery repairs and spares	-0.800 (P<0.05)	-0.909 (P<0.01)
Gross output	0.726 (P<0.01)	0.901 (P<0.01)
Imputed cost of finance		-1.132 (P<0.01)
Feed and forage cost		-0.938 (P<0.01)
Total cost of beef cattle purchases and transfers		-0.926 (P<0.010
Property maintenance and water costs		-0.753 (P<0.01)

Table 14: Summary of financial performance indicators associations with net margin/unit increase for Stocktake suckler and grower/finisher datasets

Conclusions

Multiple regression allows the effects of several predictor variables (performance indicators in this case) on an outcome variable (net margin per unit in this case) to be evaluated simultaneously. Several significant associations were identified in the suckler herd dataset, both in the physical performance indicator model and the financial performance indicator model. Although no significant associations between physical performance indicators and net margin/head output in the grower/finisher dataset were identified, the model did illustrate significant associations of net margin/head of output with several financial performance indicators. The lack of clarity in the physical performance indicator model is probably due to there being too few data points and there being too much ‘noise’ (i.e. too many other things introducing variation). Further analysis using alternative statistical techniques will be investigated in order to analyse this data further. Simulation modelling is also particularly useful in these situations, and this method will be investigated to further clarify these relationships during the second part of the project.

Appraisal of farmer attitudes to recording and using data

Introduction

This project aimed to evaluate how measuring and recording information on farm can help farmers maximise the productivity of their beef enterprises. A component of this overall aim is to gain a deeper understanding of what data is routinely recorded on farm, how this information is captured and where it is stored, as well as finding out more about the challenges hindering farmers recording and using data. One of the main objectives of this questionnaire was to expand the guidance of the TAG and allow incorporation of the opinion of a wider variety of farmers with different enterprise types, to ensure the outputs of the project are relevant to as many beef farmers as possible across the sector. Distribution of the questionnaire has allowed collection of a wide variety of farmer opinion from many areas of the UK, and covering many sectors of the beef industry.

As well as providing an insight into what data beef farmers currently record, how this information is captured, where it is stored and what is used for, this information has been used to inform herd management software providers on how their products can best meet the needs of beef farmers, and helped ensure that data capture and analysis guidance and advice provided to farmers is realistic and relevant to the beef industry in the UK.

Questionnaire design

The aim of this questionnaire was to evaluate what data is currently recorded on beef enterprises in the UK, how this data is captured, stored and analysed, and what the perceived challenges to data collection and analysis are amongst beef farmers. A pilot questionnaire was designed with these aims in mind, and was distributed during two farm walks conducted as part of the project. Following this, five semi-structured interviews with beef farmers were conducted by phone to further inform question design. The amended questionnaire was then posted on Survey Monkey (www.surveymonkey.com) and a link distributed via a contact list of beef farmers held by AHDB.

Data collection and cleaning

143 responses were collected over the 3 months the questionnaire was open. These were downloaded from Survey Monkey into Microsoft Excel for analysis. Three responses were deleted during data cleaning as they were largely incomplete. Where appropriate, free text question responses were grouped into suitable categories for analysis. For example, an extra herd type category ‘Mix’ was added as several free text responses describing enterprise type stated that a mix of enterprise types were combined (often a suckler herd alongside buying in extra growers/finishers). Following data cleaning, the questions were divided into four sections for analysis:

1. Herd details
2. Herd management software and electronic identification (EID) use
3. Data recording
4. Data use

Results

Herd details

Respondents were from 39 counties (North, South, East and West Yorkshire were grouped together), mainly in England, but also including Wales, Scotland and Northern Ireland. The highest number of respondents were from Yorkshire, closely followed by Durham, Cumbria and Devon.

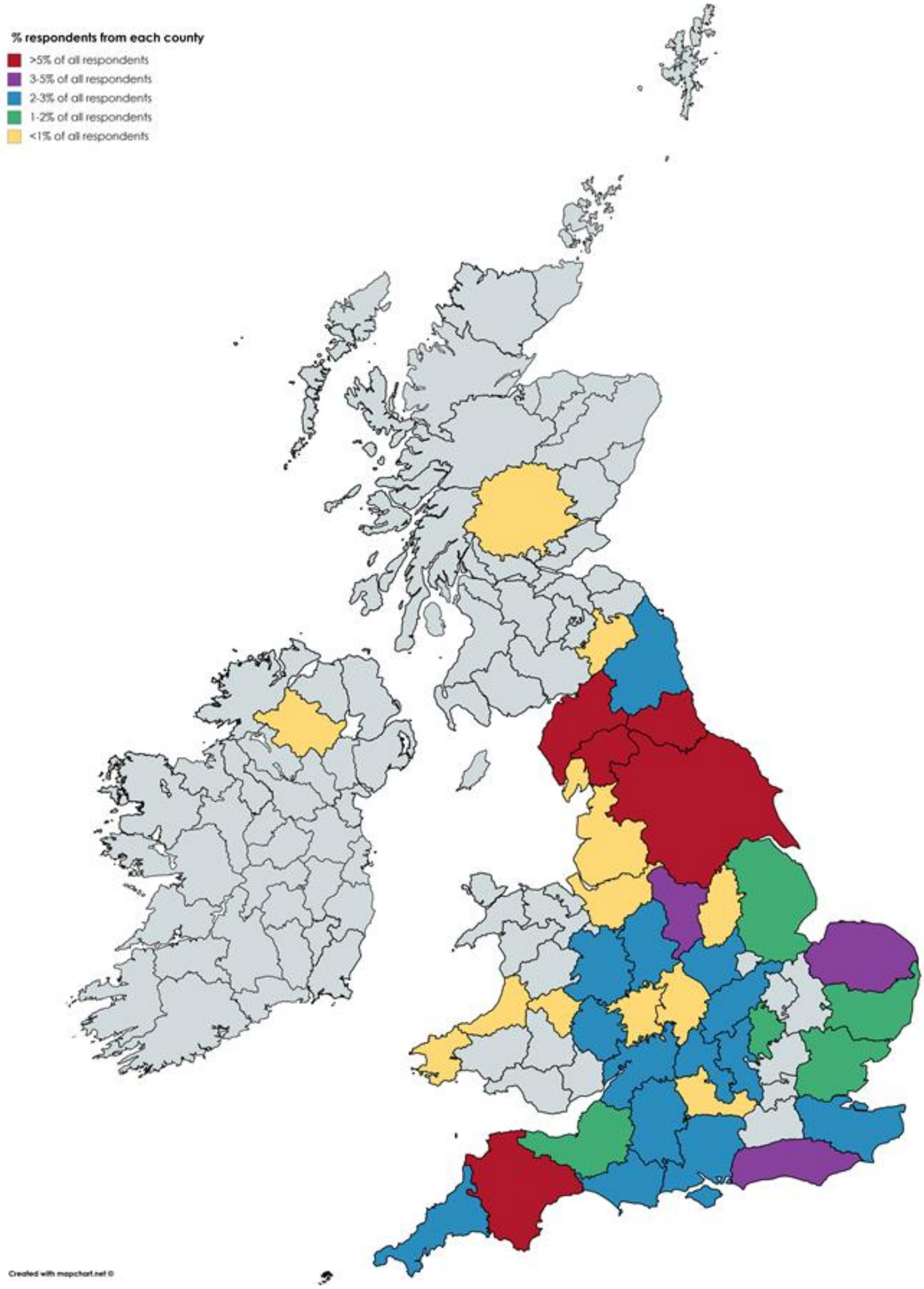


Figure 26: Percent of respondents from each county

The large majority of the respondents classed their herd type as ‘Suckler’, as shown below. This may be a reflection of the types of enterprise for which contact details are held by AHDB, and the type of enterprise interested in farm walks/meetings on data analysis and use.

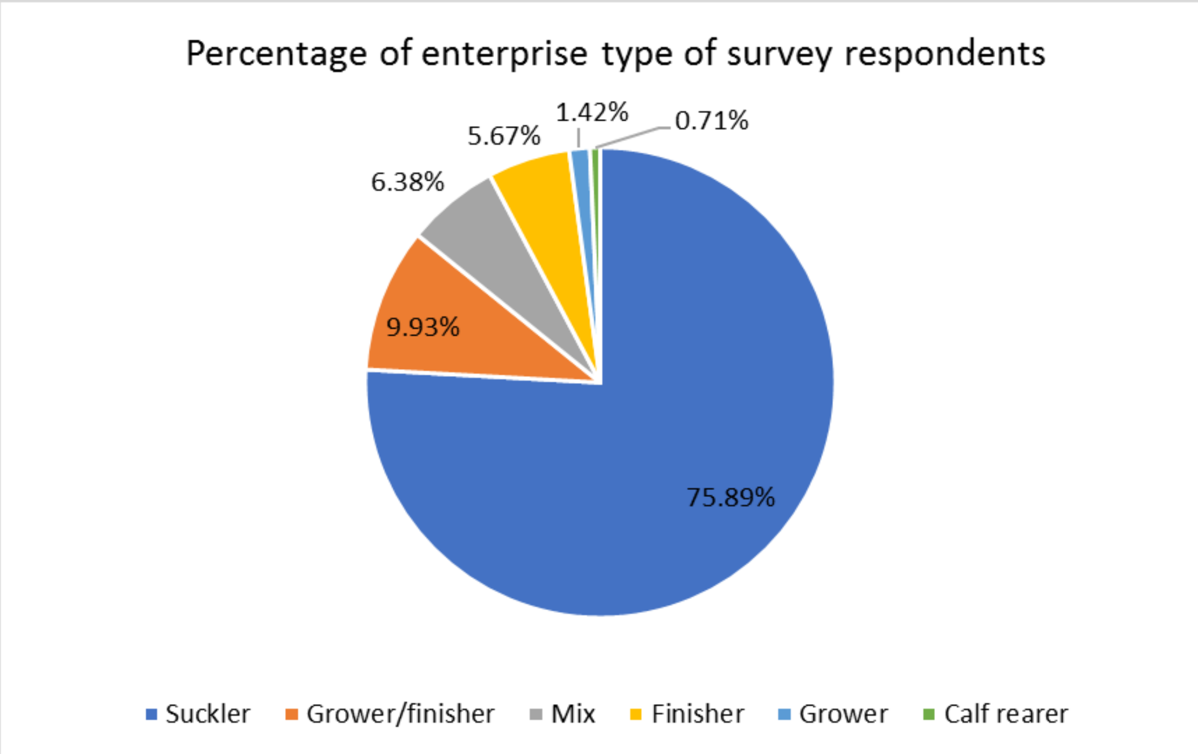


Figure 27: Pie chart of enterprise types of survey respondents

The median herd size of the suckler herds was 75 (mean 101), the largest being 1300 and the smallest being 7. Several outlier values in the herd size category means that using a median average is more appropriate than a mean in this case (although mean values are also provided). Of 140 responses, 125 (89%) had an additional enterprise/enterprises, sheep and arable being the most common. The average number of staff (full time equivalents) varied between the enterprise types, with mixed enterprises (i.e. those having a suckler herd with additional growers/finishers) having the highest number of staff, and growers/calf rearers having the lowest. When herd size was taken into account however, suckler enterprises had the lowest number of head/staff member, closely followed by grower/finisher enterprises (although there are small numbers of respondents in every category other than suckler).

ENTERPRISE TYPE	NUMBER OF RESPONDENTS	AVERAGE HERD SIZE	AVERAGE NUMBER OF STAFF	AVERAGE HEAD/STAFF MEMBER
SUCKLER	106	101	1.3	70
FINISHER	8	410	1.7	210
GROWER/FINISHER	14	130	1.2	107
CALF REARER	1	200	1.0	200
GROWER	2	190	1.0	190
MIXED	9	509	1.9	229

Table 15: Herd size and number of full time equivalent staff in different enterprise types.

As several of the enterprise types contained small numbers of respondents, some were combined and 3 categories were created: ‘Suckler’ (n=107), ‘Grower/finisher’ (n=14) and ‘Other’ (n=20).

ENTERPRISE TYPE	NUMBER OF RESPONDENTS	AVERAGE HERD SIZE	AVERAGE NUMBER OF STAFF	AVERAGE HEAD/STAFF MEMBER
SUCKLER	107	101	1.3	71
GROWER/FINISHER	14	130	1.2	107
OTHER	20	422	1.7	215

Table 16: Herd size and number of full time equivalent staff in combined enterprise types

Herd management software and EID use

Almost half of respondents use some form of herd management software (48%). This varied between different herd types, as illustrated in the table below.

ENTERPRISE TYPE	NUMBER OF RESPONDENTS	% YES	% NO
SUCKLER	104	50	50
GROWER/FINISHER	14	21	79
OTHER	18	55	45

Table 17: Software use in different enterprise types

This shows that half of suckler herds use herd management software, and that use tends to be higher in suckler herds than grower/finisher herds. The significance of this was tested with a Chi-squared test and was found to be not statistically significant (P=0.10).

The median herd size of herds using software is 100 (mean 216), whereas for herds not using software it is 50 (mean 88). The median number of head/staff member (full time equivalent) for enterprises using herd management software was 80 (mean 123), whereas for those not using software it was 48 (mean 73.) These both suggest that larger herds are more likely to use herd management software. This was found to be statistically significant using a Mann-Whitney U test ($P<0.01$). Herd size being too small was also a popular reason stated by respondents for not using herd management software, as illustrated in Figure 28.

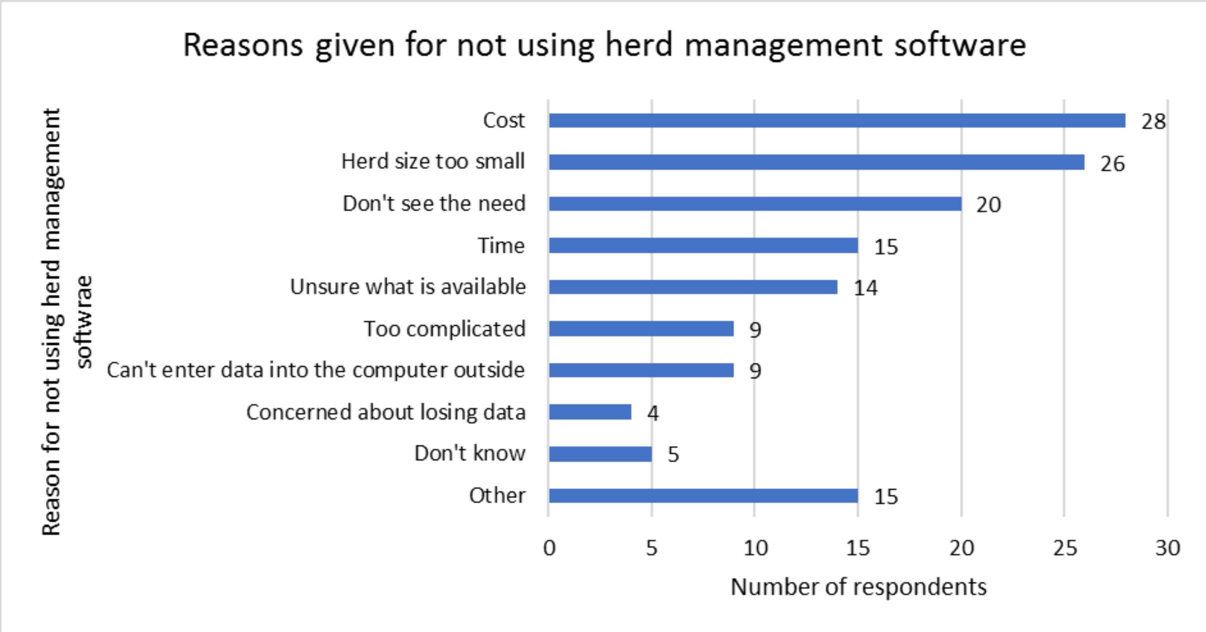


Figure 28: Bar chart of reasons given for not using herd management software

71 respondents reported that they don't use any herd management software. The most popular reason given for not using herd management software was cost (28 responses/39% of those that don't use software), but having a small herd and not seeing the need were also popular responses (26 responses/37% and 20 responses/28%respectively). A lack of time (21%) and being unsure what software is available (20%) were the next most popular answers, followed by feeling that software is too complicated and a desire to be able to enter data 'crush-side' (both 13%). 5% of those that don't use software were concerned about losing data, and 7% didn't know why they didn't use any herd management software. 15 respondents gave other reasons for not using software. These included lack of IT skills/knowledge, use of their own spreadsheet system, concerns about transferring data if software becomes obsolete, and having to record data manually elsewhere in addition to recording it in software. 3 respondents also expressed plans to use software in the future.

18 software types were recorded by 65 respondents using herd management software, and interestingly 14% of those using software stated that they used their

own home-made and bespoke spreadsheets/databases. When questioned about what they liked about their herd management software, ease of data entry was the most popular response (46 responses/71% of those that use software), as illustrated in Figure 29. The way the data is displayed and the reports generated were the next most popular responses(49% and 45% respectively of those that use software), followed by the ability to record data for multiple enterprises (23%), KPI calculation (22%) and benchmarking (18%). 4 people liked that their software was compatible with others (6%). 13 people gave other reasons for liking their software, these included the ability to link with BCMS/CTS, the availability of a cloud based facility allowing easy access for multiple people and in different places, and the flexibility/ability to customise and modify software to an individual farms requirements.

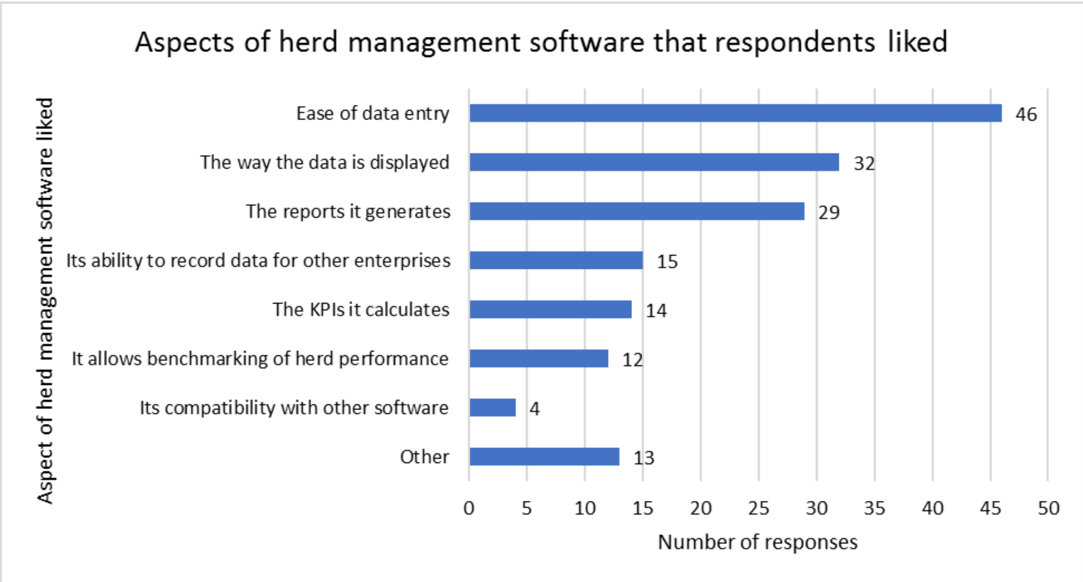


Figure 29: Bar chart of aspects of herd management software respondents liked

Of the 65 respondents that use herd management software, 41 commented on what they would change about the software they currently use. Several themes emerged amongst these comments:

- 8 said they wouldn't change anything about the software they currently use (although some of the 'non-responses' to this question could also indicate this).
- 6 said they would change the reports that their software generated, for example to include cow efficiency reports, reports including cattle no longer on the holding, and reports incorporating sire and EBV (estimated breeding value) information.

- 4 commented that they would like their software to allow them to record data remotely i.e. ‘in the field’ via an app, and to be cloud based to allow multiple people access in multiple places.
- 4 commented that they would like their software to be more compatible with other systems, for example financial programmes, other systems on farm such as diet feeders, and Signet.
- 3 would like their software to record more, and examples given included veterinary and medicine data, grassland management information, and 200 day/400 day weights.
- 3 thought their software was too complicated and would like it to be easier to use and to get the information out that they require.
- 2 would like their software to allow benchmarking.
- 2 would like their software to be more beef focussed, and not a slightly altered dairy program.

16% of respondents use EID in their beef herd (33% of herds that use management software). The median herd size of those using EID is 105 (mean = 315), whereas the median herd size of those not using EID is 75 (mean 106). This suggests, as is the case with herd management software uptake, that it is currently the larger herds that are more likely to use this technology. This however is not statistically significant (P=0.57) which could be due to the smaller number of herds using EID meaning a smaller sample size is available. Again, the use of EID varies between enterprise types, as illustrated in the table below.

ENTERPRISE TYPE	NUMBER OF RESPONDENTS	% YES	% NO
SUCKLER	104	14	86
GROWER/FINISHER	13	8	92
OTHER	18	33	67

Table 18: EID use in different enterprise types

Again use appears to be higher in suckler herds than grower/finisher herds, although this is not statistically significant (P=0.09).

The aspect of EID found most useful by the respondents was enabling easy and quick recording of data, however providing better traceability of animals along the supply chain was also commented on. The main reason respondents gave for not using EID was not seeing the need for it (57 respondents/50% of those not using EID), although cost of the equipment (tag reader and software etc.) was also a common reason (37 respondents/33% of those not using EID). 25 respondents (22%) expressed a desire to move to EID in the future. 19 respondents (17%) quoted the cost of EID tags as a reason for not adopting it, and 15 respondents (13%) don't use it as it is not compulsory. Reasons for not using EID given under 'other' included that it wasn't economically justifiable, a lack of compatibility with the current software used, and that manual data entry would still be required.

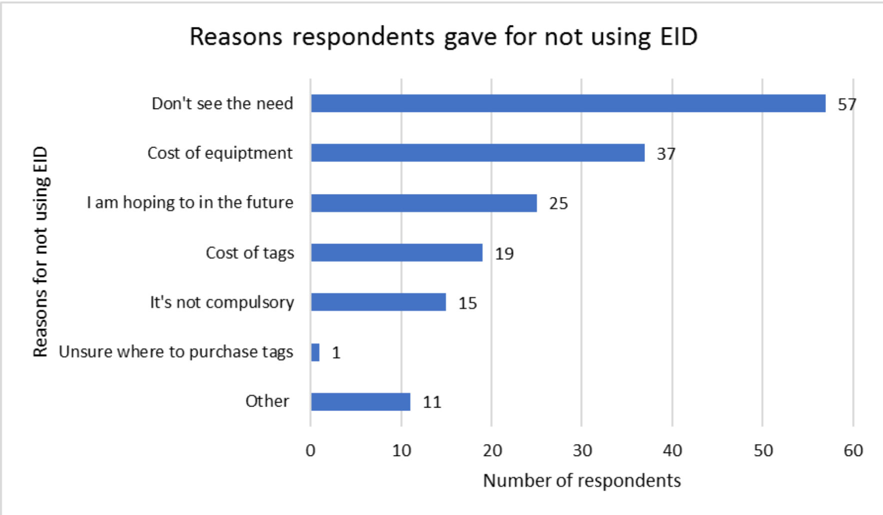


Figure 30: Bar chart of reasons respondents gave for not using EID

Data recording

The following table indicates what data respondents record and where they record it. The numbers indicate the number of respondents recording that data type in each place (if they record data in multiple places they were asked to tick multiple boxes). In general paper based systems appear to be most popular, although for recording weights and movements herd management software was more popular.

	Herd management software	Paper based system	Online statutory recording	Don't record
Weights	54	52	4	36
Feed intake	16	36	0	65
Calving events	58	69	49	11
Bull in/out/AI dates	37	80	2	13
PD results	40	66	1	23
Calving ease	40	64	4	28
Medicine use	47	90	7	0

Reason for medicine use	42	84	7	3
Lameness	32	51	3	40
Individual animal infectious disease status	30	61	2	31
Abattoir feedback	34	55	5	42
Movements	60	48	80	1
Financial	29	56	1	34

Table 19: What data respondents record and where they record it

Data most infrequently recorded is feed intake, closely followed by abattoir feedback, lameness, weights and financial data. All respondents record medicine use, and all but one record movements (although this is a statutory requirement so this may represent a mistake in answering the questionnaire or misunderstanding the question). Where respondents indicated that they recorded data elsewhere, it was largely in home-made bespoke spreadsheets (10 respondents).

71 respondents would like to record more data, of these 42% (30) would like to record weight data. The next most popular answer was FCR (feed conversion ratio)/feed intake, which was suggested by 15% (11) of those that would like to record more. 3 respondents would like to record more financial data, and 2 suggested cow efficiency, grass growth and health status. 2 respondents also commented that they felt they didn't make the best use of the data that they already record, and would like to focus on this rather than recording more data. Of the respondents that would like to record more data, time was quoted as the main reason that they didn't (40 responses, 36%). 31(28%) quoted lack of technology and 19 (17%) quoted cost. 22 gave other reasons, these included lack of knowledge and understanding of technology, lack of a weigher, and difficulty weighing cattle when out at pasture.

Data use

47 respondents use their data at least once a month. This category of frequency of data use also has the highest average herd size (median = 94), as shown in Figure 31. This graph suggests that larger herds tend to use data more frequently. Frequency of data use also varied with herd type, as illustrated in Figure 32. Due to small numbers of respondents with herd types other than suckler, it is difficult to identify clear trends.

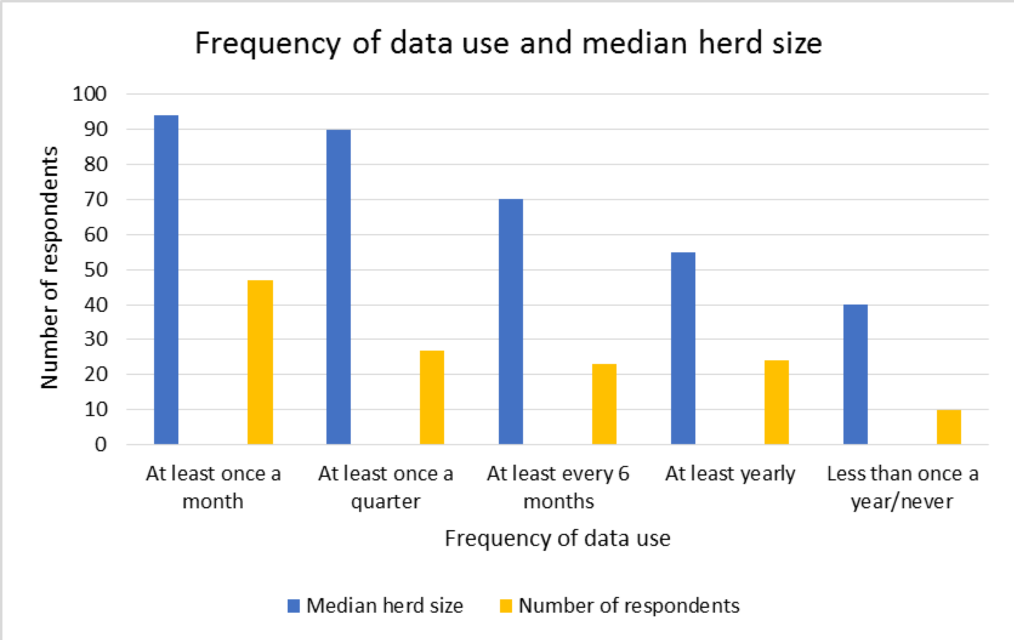


Figure 31: Bar chart of how frequently respondents use their data and herd size

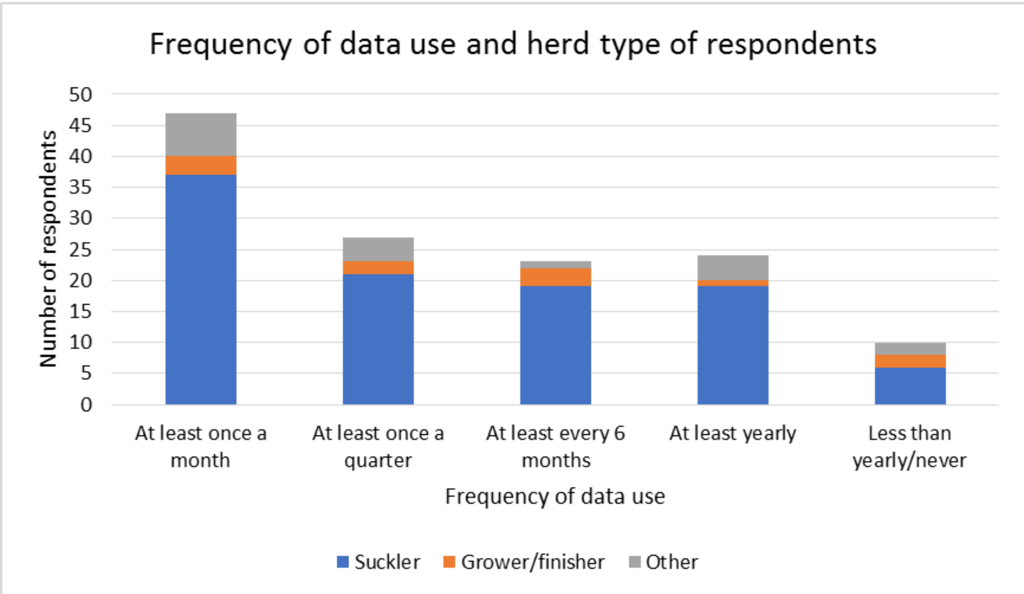


Figure 32: Bar chart of how frequently respondents use their data and enterprise type

Respondents were asked how they use the data that they record, and the responses are illustrated in Figure 33. The most popular use was for individual animal management (86 responses/61% of all respondents), closely followed by making breeding decisions (83 responses/59%) and monitoring herd performance (76 responses/54%). Financial management was the fourth most popular data use category with 60 respondents reporting that they use their data for this (43%). Comments made in the ‘other’ category included monitoring ration plans, for gaining accredited heard health status/farm assurance, and for promotion of the herd. One respondent was very honest when describing why he didn't use his data: 'Having no longer got a software system, I am bad at collating the information manually, every now and again I might work out cost of finishing bulls etc., Normally with the price of beef it becomes a depressing exercise, therefore I am not enthused about too regularly working out that I am the proud owner of expensive lawnmowers'.

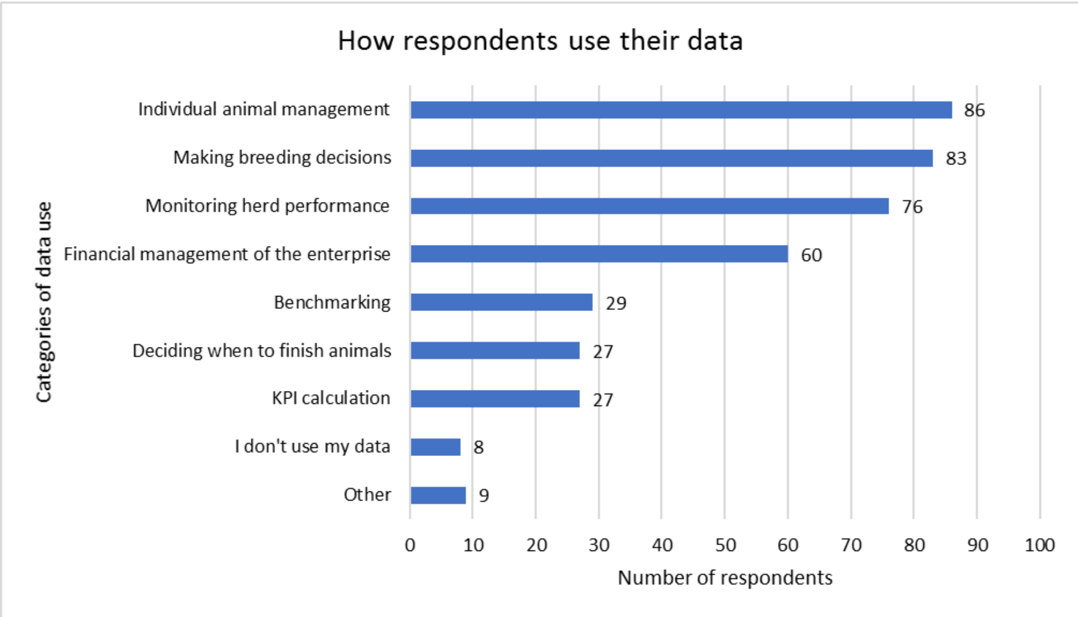


Figure 33: Bar chart of how respondents use their data

When asked about ease of data analysis, it appears that respondents tend to find data collection easier than analysis (although the gap is very small), as illustrated in Figure 34. This highlights an area where more guidance could be provided for farmers to assist with these perceived difficulties.

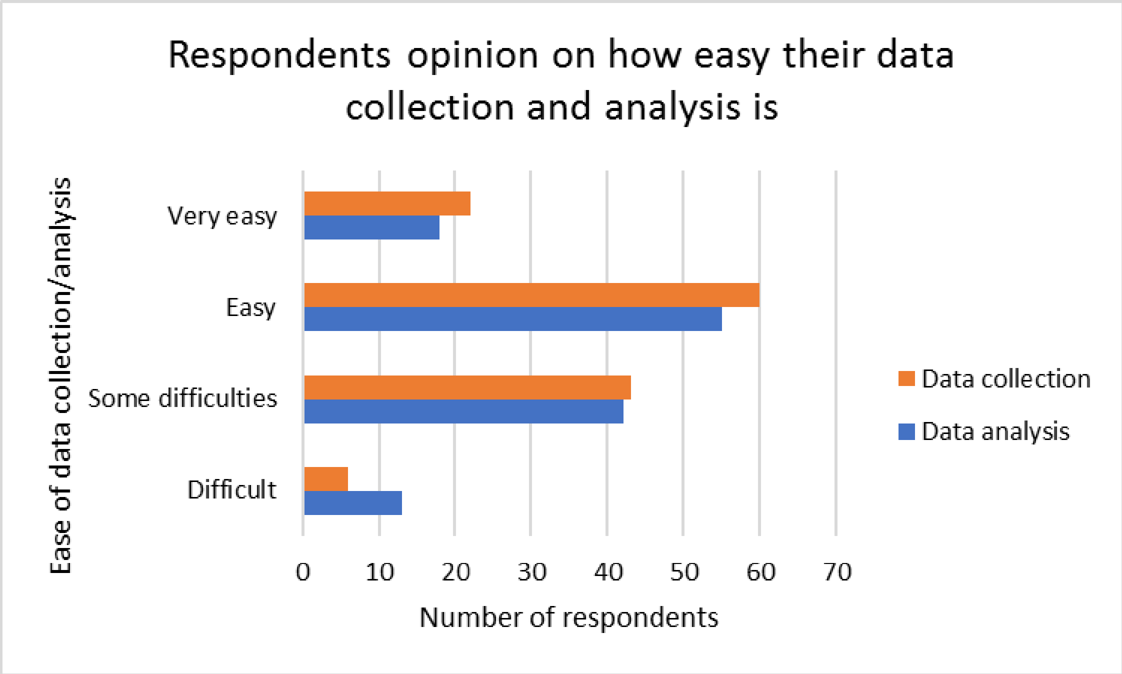


Figure 34: Bar chart of respondents' opinion on ease of data collection and analysis

Respondents were asked to score how valuable they perceived their data to be for their enterprise (with 1 being unimportant and 100 being very important). The median score across all respondents was 80 (mean=76). Scores ranged from 0 – 100, but the skewed distribution, illustrated in the histogram below, shows that in general farmers do value their data

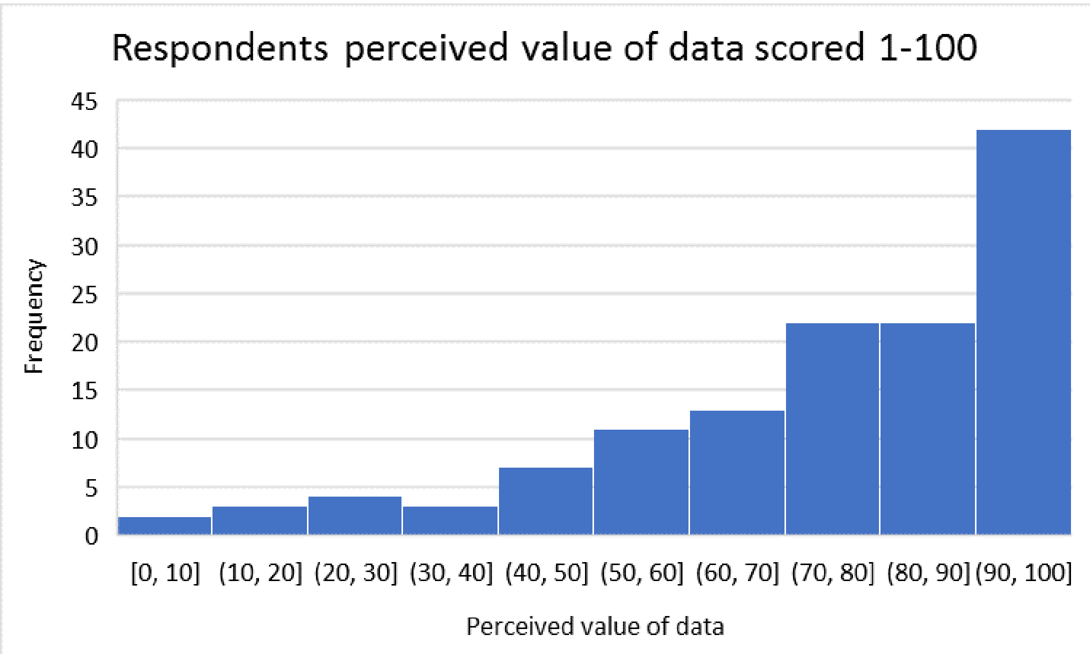


Figure 35: Histogram of respondents' perceived value of data

Figure 36 shows these scores against herd size and for different herd types. Here we can see that large herd sizes do tend to perceive collection and analysis of data as being of value, but there is more varied opinion amongst smaller herds. There is a large variation in the perceived value of data amongst suckler enterprises, which represent the majority of the respondents, however respondents with finisher and mixed enterprises tend to value data more highly.

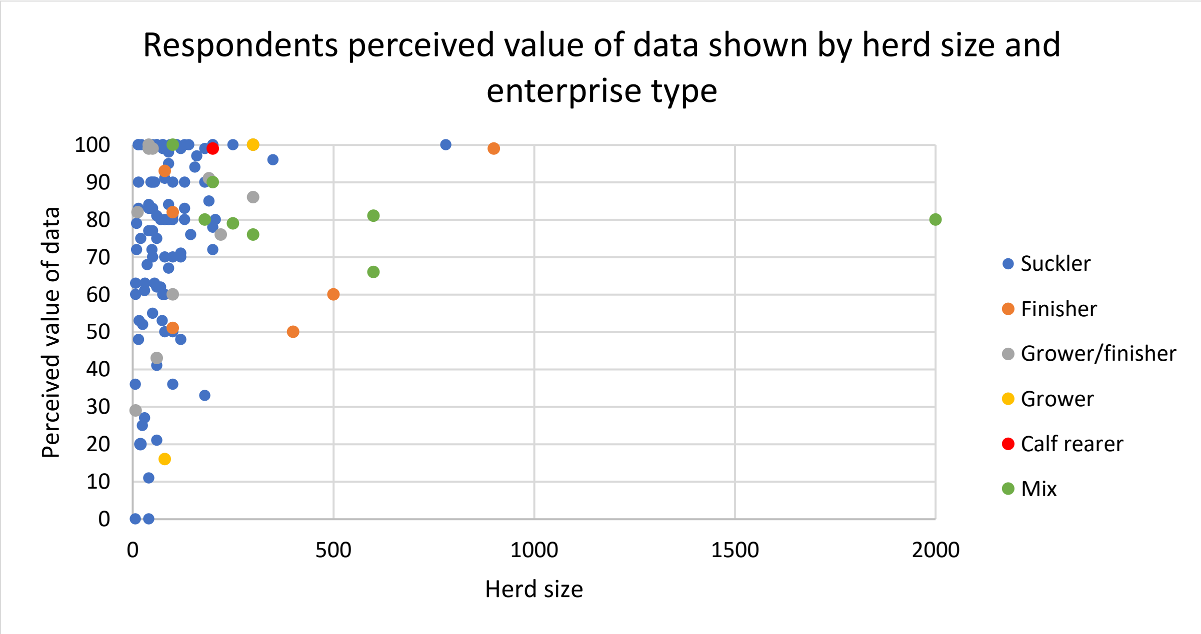


Figure 36: Scatter plot of respondents' perceived value of data, herd size and enterprise type

Summary and discussion

- 143 responses were collected over 3 months. Respondents farmed in 39 counties, mainly in England, but also incorporating Wales, Scotland and Northern Ireland. Suckler enterprises made up 76% of respondents, and herd size ranged from 7 to 2000. Questionnaires were distributed via and AHDB mailing list and at farm walks and benchmarking meetings. This may have introduced a degree of selection bias, however the aim of the questionnaire was to incorporate a wider variety of farmer opinion than available in the TAG, and this was achieved.
- 48% of respondents used some form of herd management software. This appeared to vary by enterprise type, although this was not statistically significant. Larger herds were however more likely to use herd management

software (P<0.01). Cost, and herd size being too small were the most popular reasons given for not using herd management software.

- 14% of respondents using software used home-made bespoke programs. The most popular aspects of herd management software that respondents liked were ease of data entry, the way the data was displayed and the reports generated. However, when asked what they would change about their software, adding information to the reports generated was a common theme. Other popular responses included the ability of software to be compatible with other programs, and the ability to enter data remotely and for the system to be cloud based.
- 16% of respondents use EID in their beef enterprise, and again this appears to be more common in larger herds (although this was not statistically significant). The aspect of EID found most useful by the respondents was enabling quick and easy recording of data, however providing better traceability of animals along the supply chain was also commented on. The main reason respondents gave for not using EID was not seeing the need for it, although cost of the equipment (tag reader and software etc.) was also a common reason given.
- When questioned about where data is recorded, paper based systems appear to be the most popular for most data types. Half of respondents would like to record more data, and of these weight data was the most common thing respondents would like to record. Time was the most popular reason for not recording more data, closely followed by lack of technology.
- 47 respondents use their data at least once a month, and again larger herds appear to use data more often. The most popular ways that respondents used their data was for individual animal management, making breeding decisions and monitoring herd performance.
- When questioned about ease of data collection and analysis, it appears that respondents tend to find data collection easier than analysis (although the difference is small).
- Respondents generally see the value in collecting and using data to help manage their enterprises, with a median value score collected of 80 (1 being not important and 100 being very important). It must be considered however that those farmers on the AHDB mailing list, and those choosing to complete

the questionnaire, are likely to be those with an interest in data recording and analysis, so the sample is inherently biased. However, the aim of this questionnaire was to incorporate a wider selection of opinions than that of just the TAG members, and this aim has been achieved.

Conclusions

Farmers in this sample tended to value their data highly, and many would like to record more or make better use of what they currently collect. Almost half of respondents use herd management software, but over 50% of these commented on aspects of their software that could be improved to better meet their needs. Data analysis appeared to be viewed as slightly more challenging than data collection by respondents, indicating that this could be an area where increased guidance for farmers could be particularly effective in overcoming challenges to data use. Other than cost and time, lack of technology and knowledge were commonly quoted barriers to data collection and use.

Knowledge exchange activities

The aim of this project is to add significant information towards the development of KPIs for the beef industry in England. In order for this to have maximum impact on the industry, knowledge exchange represented a core component of the project. Knowledge exchange activities have included case study articles written around the TAG farms, attendance at events such as 'Beef Expo' (the National Beef Association's annual event), farm walks and filming events held on each of the TAG farms with the aim of illustrating the value of data recording and KPI use in order to engage more farmers in performance monitoring, and speaking at AHDB's Consultants' Days and Developing Beef Expertise workshop, as well as at appropriate conferences (such as BCVA Congress) and beef benchmarking groups around the country. Further knowledge exchange activities planned for the second part of the project include production of further articles and a webinar outlining the outcomes of the project.

Completed events:		
Knowledge exchange event	**Location**	**Date**
Presentation at AHDB developing beef expertise workshop	Lancashire	December 2015
Presentation at AHDB beef and lamb consultant's day	Warwickshire	September 2016
Film produced about using data to inform decision-making in finisher enterprises	Lincolnshire	October 2016
Presented poster about project at the British Cattle Veterinary Association congress	Warwickshire	October 2016
Farm walk – using data to make better decisions in a suckler enterprise	Oxfordshire	November 2016
Farm walk – using data to make better decisions in a grower/finisher enterprise	Herefordshire	November 2016
Articles – 8 articles produced, 2 for each TAG farm, focussing on how their data is used to inform decision-making.		March 2017
Produced posters for and attended Beef Expo	Warwickshire	May 2017
Film produced about using data to inform decision-making in suckler enterprises.	Oxfordshire	June 2017
Talking to beef benchmarking groups	Nationwide	Throughout 2017
Planned events:		
Presentation about project at the British Cattle Veterinary Association congress	Lancashire	October 2017
Farm walk – using data to make better decisions in a grower/finisher enterprise	Herefordshire	Autumn 2017

Articles – 4 further articles describing findings from the second part of the project.		Spring/ summer 2018
Webinar outlining project outputs		Spring/ summer 2018

Table 20: Summary of knowledge exchange activities completed and planned

Future plans

During the second part of the project, stochastic modelling will be used to derive additional value from the data collected and analysed so far. By investigating more complex scenarios, the impact of management changes on overall enterprise success will be further clarified in the different systems. Stochastic modelling allows for uncertainty in the outcomes of a system. Farms are complex systems with many confounding variables affecting an outcome, making outcomes uncertain. Calculations relating system inputs to outputs are done a large number of times to create a dataset. Analysis of this dataset can then be used to explore the relationship between input and output. As the user chooses the inputs for the models there is a degree of subjectivity; in this project it is anticipated that the expert opinion gained from the TAG will counteract this. It is anticipated that the TAG will remain involved during this period to provide guidance on this aspect of the project. The time scale for this is July 2017 to July 2018.

Table of deliverables and milestones

Deliverable/milestone	Date delivered/completed
Speaking at AHDB Developing Beef Expertise workshop	December 2015
Initial literature review and identification of key opinion leaders.	April 2016
Co-ordinate six technical advisory group (TAG) meetings (1 by teleconference)	May 2017
Workshop meeting involving wider expert group in addition to TAG members (first of TAG group meetings)	January 2016
Data collection from TAG, KPI calculation and analysis of trends over time	July 2016
Speaking at AHDB consultants day	September 2016
Analysis of correlations between KPIs and overall enterprise success	February 2017
Production of 8 articles using TAG farms as ‘case-studies’	March 2017
Questionnaire appraisal of farmer attitudes to recording and using data	April 2017
Attendance at Beef Expo	May 2017
Two on-farm events per TAG farm (One agreed to be completed during second half of project due to circumstances outside of farmers and project members control)	June 2017
Production of final report for AHDB	June 2017
Quarterly project updates to AHDB	March 2016, June 2016, September 2016, December 2016, March 2017, June 2017

Table 21: Summary of deliverables and milestones

Acknowledgements

I’d like to thank the technical advisory group for their guidance and input throughout this project, and for providing data for analysis. For the funding provided, I’d like to thank AHDB Beef and Lamb and the University of Nottingham. I’d also like to thank my supervisors, Dr Chris Hudson and Professor Martin Green, for their help and support during the project and in creating this report.

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