Evaluation of an electronic feeder system used in group-housed pigs

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An introduction to electronic feeders

The development of electronic feeders has enhanced the opportunities to study feed intake in livestock species. Electronic feeders have been developed for cattle, pigs and sheep with all electronic feeders having the same basic purpose and design with modifications to suit the physiological differences between the species. The present study will focus on electronic feeders used in pigs.

Before the development of electronic feeders, pigs were individually housed and the feed intake of each individual pig was manually weighed and recorded. Therefore, the use of electronic feeders, which allow pigs to be group-housed, has the potential to reduce costs in terms of both labour and housing.

Electronic feeders produce a large amount of data that is not without error (Eissen *et al*., 1998). Current literature describes data that have been edited after data collection, highlighting the challenges that are associated with classifying and rectifying errors identified. A solution is to identify errors early during data collection and where possible to rectify any problems with the system.

The aims of this evaluation were to identify errors associated with individual feed intake events, to recommend ways to reduce the error rate in the future and to evaluate the effectiveness of the recommendations made.

Commonly used electronic feeders

Internationally, there are three commonly used electronic feeders for pigs. The AMECA 48 feeder was developed in France by CEMAGREF (Centre d'Etudes du Machinisme Agricole, du Génie Rural et des Eaux et Forêts, F-35000 Rennes). The Individual Voluntary Feed Intake Recording in Group Housing feeder – IVOG – was developed by Technical and Physical Services in Agriculture, Wageningen, The Netherlands. The Feed Intake Recording Equipment – FIRE – feeders were originally developed by Hunday Electronics Ltd, Newcastle-Upon-Tyne in England with current development of these feeders carried out by Osborne Industries in Kansas, USA.

The basic design of all these feeders requires the pigs to have an electronic ear tag containing identification information. This electronic ear tag is read by an antennae located in the electronic feeder. Also, all these electronic feeders have some sort of feed trough/dispenser and a mechanism to weigh the feed. However, all these feeders have different design features that affect the level of feed wastage and the possible level of disturbance whilst feeding.

Data collected from electronic feeders

The data collected from the electronic feeders provide information on feeding events of individual pigs. A record contains the pig's identification number, the time and date of the feeding event, the amount of feed eaten in that feeding event and the time spent feeding.

This information can be used in genetic analyses to estimate the heritabilities of feeding pattern traits and genetic correlations between feeding pattern traits and production traits such as feed conversion ratio and lean meat growth. The genetic correlations estimated show the strength and direction of the relationship between feeding pattern and production traits, which may suggest feeding pattern traits that would be informative selection criteria. Feeding pattern traits may also provide information on the health status of individual pigs during test since sick pigs may be characterised by periodically low daily feed intake. This information may be used in selection programs to improve selection of pigs that are able to adapt best to the constraints that a commercial environment with group-housing imposes on their performance.

The Bunge Meat Industries electronic feeders

The feeders used in the present study to collect individual feed intake data have been developed in-house at Bunge Meat Industries (BMI). A major difference between the previously described internationally developed feeders and the BMI feeder was that the BMI feeder continually dispensed feed at a pre-set rate throughout the feeding event. The rate of feeding is set manually outside of the pen.

There were three other unique features to the BMI electronic feeder system as well as the continuous dispensing of feed. One is the weight scales that were fitted to the electronic feeder. The automatic weighing scales allowed repeated weight measurements to be recorded during the test period. Another is that the BMI electronic feeder operation had the capability to allocate pigs to one of three feeding levels in each pen. Feeding levels increased each week to allow for the extra maintenance requirements of the pigs. Finally, a 'credit' system was in place in which any feed not eaten in a day was added to the allowance of the next day. This was accumulated within a week and any credit of feed was lost when the allowed feed intake was increased the following week.

Every pen contained three electronic feeders. Each electronic feeder consisted of a feeding trough, an antennae located behind the trough and race walls that were constructed of sheet metal, preventing pigs from seeing each other whilst feeding. The chance of pigs being chased out of a feeder was minimal due to the protected sides of the feeder, although disruptions to feeding events from other pigs were possible from the rear. At least one feeder in each pen was equipped with automatic weighing scales.

Each electronic feeder was equipped with a laser beam across the race and an antenna behind the feed trough. The electronic feeders began operation when a pig entered the feeder and the laser beam across the race was broken. This in turn triggered the antenna to read the pig's identification number from a transponder located in an ear tag. The feeding event ended when the pig broke the laser beam on exit.

Error detection

Eissen *et al*. (1998) stated that it would be useful to detect and rectify errors during the test period. Studies carried out by Eissen *et al.* (1998), which were then expanded by Casey and Dekkers (2001), developed algorithms to monitor the electronic feeder operation during the test period. The algorithms developed by Eissen *et al*. (1998) and Casey and Dekkers (2001) were specific to the electronic feeder used in their respective studies, the IVOG and FIRE feeders. These algorithms were not applicable to the electronic feeders used in the present study because of the differences in design and management between the BMI, IVOG and FIRE feeder systems. Therefore, they could not be used to identify errors in the feed intake data in this study.

A new approach was needed to evaluate and identify errors with the feeder system used in the present study. To do this, a new trait was defined and was used as a tool to investigate the data for errors. This new trait (DIFF) was defined as the difference between the observed weekly feed intake and the allowed weekly feed intake of a pig. This trait allowed the identification of factors that may cause a reduction in the feed intake of the pig and may identify problem areas with the electronic feeders.

The analysis

In this study two data sets were compared to assess the effectiveness the electronic feeders developed at BMI and the recommendations made and implemented in between the collection of the two data sets. The first data set, DATA1, was collected between February and August 2000, and consisted of 107,127 feeding records from 278 boars with an average starting weight of 73 kg. An analysis was carried out on this data set and recommendations were made based upon the results of this analysis. After the recommendations had been implemented, the second data set was collected and the same analysis was carried out. The second data set, DATA2, was collected from February to May 2001 and consisted of 126,430 from 275 boars with an average starting weight of 70.2 kg. Each data set consisted of 10 pens of approximately 30 boars in both DATA1 and DATA2.

The trait DIFF was analysed using PROC GLM in SAS (1988) and Least Square Means (LSM) were calculated for each fixed effect. The fixed effects tested were week, feeding level, start weight class (STWT – classed into 5kg intervals), weekly rate of feeding (WROF – classed into 0.05 g/sec intervals), number of visits per week (NVWEEK – classed into 10 visit intervals) and pen.

Results & Discussion

DATA1

The magnitude of DIFF was large when the NVWEEK was below 20 (Figure 1). This would indicate pigs that were sick or had lost an ear tag. However, the magnitude of DIFF was also large when the NVWEEK was above 190, suggesting that the pigs were eating well below their allowance whilst visiting the feeders frequently. This trend may indicate a possible disturbance or interference to the pigs whilst feeding.

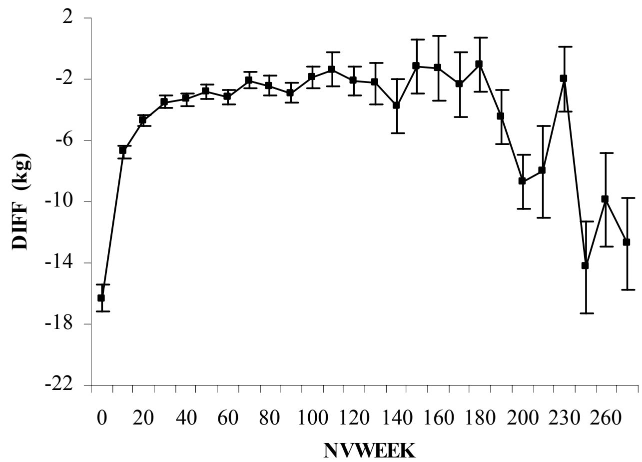

FIGURE 1. Least Square Means of the difference between actual and allowed feed intake (DIFF) for the number of visits per week (NVWEEK) in DATA1

Another possible interference is illustrated in Figure 2 where an increase in the magnitude of DIFF during the later part of the test period corresponded to an increase in the average NVWEEK for each testing week. This again suggests that the pigs were visiting the feeders more often while eating below their allowance.

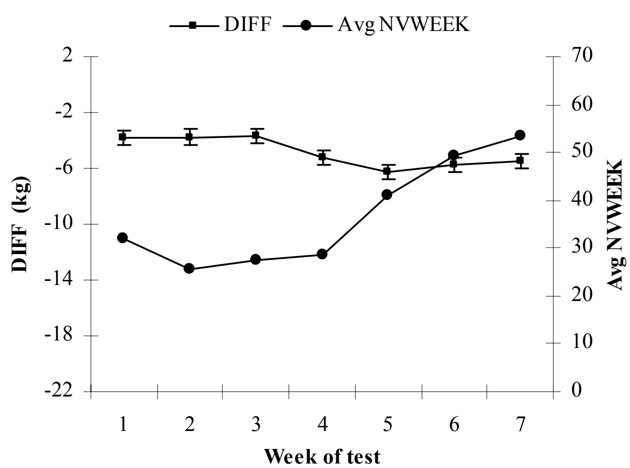

FIGURE 2. Least Square Means of the difference between actual and allowed feed intake (DIFF) for week – including the average NVWEEK in DATA1

In DATA1, STWT did have an effect on DIFF, with the magnitude of DIFF decreasing as start weight increased (Figure 3). This may be expected because pigs that have a higher starting weight have higher energy maintenance requirements and are therefore expected to eat more.

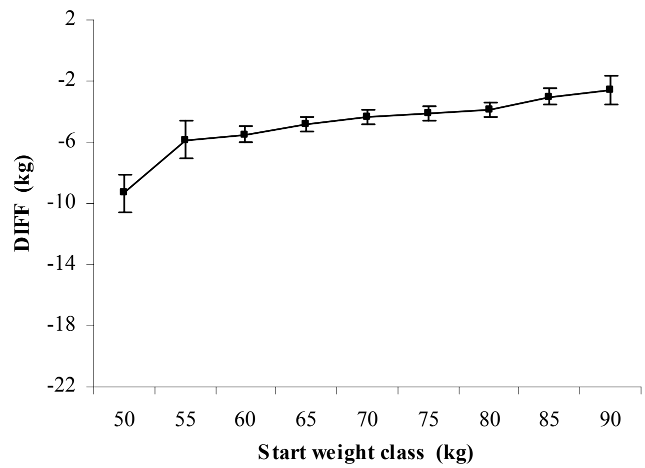

FIGURE 3. Least Square Means of the difference between actual and allowed feed intake (DIFF) for the starting weight class (STWT) in DATA1

Recommendations from DATA1

The possible disturbance to feeding events indicated by the results of the effect of NVWEEK and week on DIFF in DATA1 (Figures 1 and 2) could possibly have been due to mechanical or social effects. Mechanically, it was thought to be the laser beam in the electronic feeders. As the pigs grew and became heavier and taller, the laser beam could have been broken more often simply because the pig was moving around whilst feeding. Another possibility is an increase in social interaction. This social interaction could be aggressive due to a decrease in available space as the pigs grow or because some pigs have reached puberty and are demonstrating sexual behaviours. Due to the constraints of this project, recommendations could not be made on the possible social factors affecting feed intake. The recommendation made was to change the direction of the laser beam from being directed horizontally across the race to diagonally, in order to remove the possible mechanical factor.

From the results of the effect of start weight class on DIFF (Figure 3), the recommendation was made that the starting weight of the pig should be taken into consideration when calculating feed allowances. The starting weight of pigs was taken into consideration when allocating feeding levels in DATA2 where six feeding levels were defined based on starting weight ranges.

Other changes were made by BMI during the collection of the data. These included the development of procedures to monitor the machinery and the animals. Monitoring procedures are essential in the operation of any data collection system. The monitoring of the animals and machinery was carried out daily at BMI and was based on three daily reports. These reports were collated from the central database and were the “No Feed Report”, the “Rate of Feed Report” and the “Ratio Report”.

The “No Feed Report” listed all animals in each pen that had eaten less than 1000 grams in the previous 24-hour period. This report highlighted animals that were sick or had a malfunctioning or lost ear tag. The “Rate of Feeding Report” printed out the average rate

of feeding for each feeder in each pen and any rate of feeding that was too low or too high was altered on the feeder. The "Ratio Report" monitors a BMI specific editing procedure. For feeding events where the rate of feeding exceeded 1.5 g/sec the weight of feed eaten was reduced to equal the time, giving a rate of feeding equal to 1 g/sec. The "Ratio Report" was a list of all the feeding events for each feeder where this editing procedure had been carried out. This report highlighted any errors with a feeder.
Other factors, such as the weekly rate of feeding (WROF) and feeding level, were investigated and found to be significant but had a smaller effect on DIFF than the NVWEEK, week and start weight class. The WROF was influenced by the BMI specific editing procedure and a recommendation was made to review this procedure whilst monitoring the editing procedure using the "Ratio Report". From the combined results of the effect of feeding level and start weight class, a recommendation was made relating to the calculation of the maintenance requirements of the pig.

DATA2 – Recommendations implemented

After the changes had been implemented following the analysis of DATA1, the maximum values for NVWEEK in DATA2 were reduced to 200 visits per week (Figure 4) in comparison to 260 visits per week in DATA1 (Figure 1). Also, the higher range of NVWEEK in DATA2 (above 150 visits per week) had no significant influence on DIFF (Figure 4) in comparison to the higher ranges of NVWEEK (above 190 visits per week) in DATA1 (Figure 1). It is believed that the higher number of visits per week seen in DATA1 was due to a mechanical cause. The decrease in the NVWEEK and the fact that there was no systematic effect of NVWEEK on DIFF in DATA2 indicated that the change in direction of the laser beam was successful. The magnitude of DIFF decreased slightly over the test period until week six after which there was an increase in the magnitude of DIFF of approximately four kilograms (Figure 5). The average NVWEEK for each week during test is decreased in week seven indicating that the decrease in feed eaten is associated with fewer visits to the feeders (Figure 5).

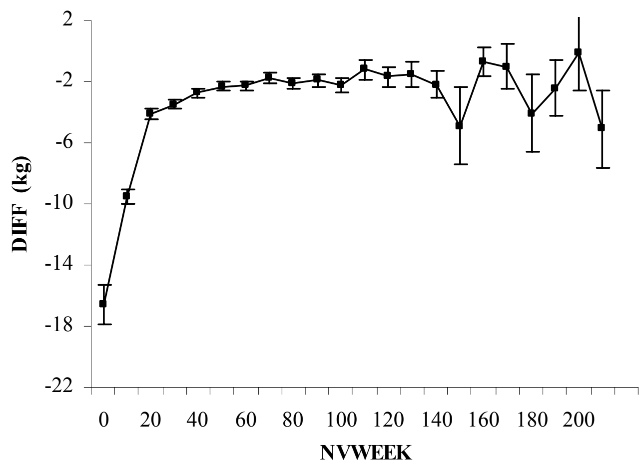

FIGURE 4. Least Square Means of the difference between actual and allowed feed intake (DIFF) for the number of visits per week (NVWEEK) in DATA2

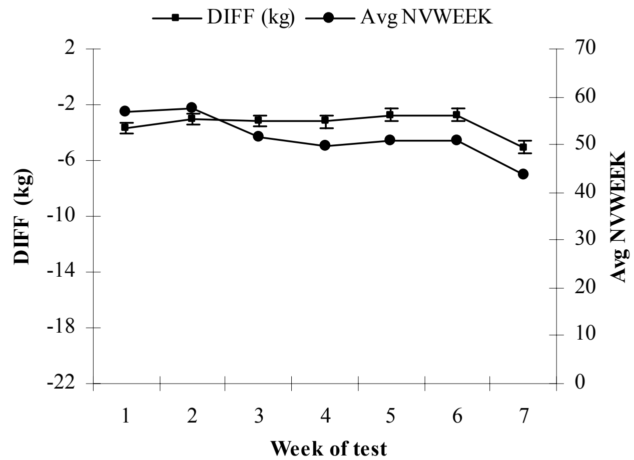

FIGURE 5. Least Square Means of the difference between actual and allowed feed intake (DIFF) for week – including the average NVWEEK in DATA2

The mechanical influence on feed intake had been removed by changing the direction of the laser beam. Therefore, the lower feed intake together with fewer visits in week seven may suggest a disturbance to the feeding behaviour of the pigs rather than a disturbance to the recording process (Figure 5). The decrease in feed intake in DATA2 in the last week of test could be attributed to several factors. One factor could be leg problems where the pig has difficulties with mobility associated with an excessive body weight. In addition, another possibility is an increase in social interaction possibly caused by a decrease in space availability or the pigs reaching puberty.

The magnitude of DIFF remained steady over start weight classes in DATA2 (Figure 6), highlighting that pigs across all start weight classes were unable to eat the given allocations by a similar factor. Kolstad and Vangen (1996) stated that it is "difficult to predict energy expenditure for maintenance in simple and general ways across animals of different physiological state and genetic background". In this study, pigs were of a different physiological state at the beginning of test, which is evident from the large variation in starting weights, 50 – 89 kg in DATA1 and 56 – 89 kg in DATA2. The pigs used in the study were also from three different lines and different genetic backgrounds with different growth potential. Therefore, due to the differences in physiological state and genetic background of the pigs used in this study, it is difficult to define an exact feeding allowance for an individual pig.

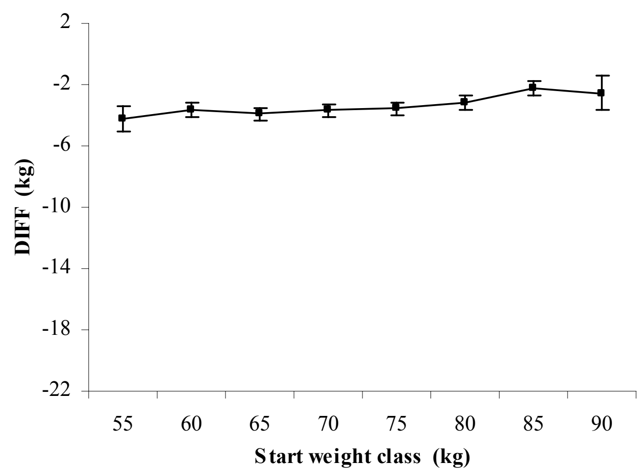

FIGURE 6. Least Square Means of the difference between actual and allowed feed intake (DIFF) for the starting weight class (STWT) in DATA2

Summary

The description of a trait has proven to be a useful tool in analysing individual feed intake data. A feature of this study was the allocation of feed allowances for pigs which were increased during each week of test. The increase in allowance was to accommodate for the increased maintenance requirements of the growing pig. The trait that was used as an analysis tool was DIFF, the difference between the observed and allotted feed intakes. The trait DIFF was used to identify factors that caused a reduction in feed intake. The effects identified causing a reduction in feed intake were the number of visits per week, week, start weight class, weekly rate of feeding and feeding level. Recommendations were based on the results of a preliminary study. The main recommendations were the change in direction of the laser beam and basing the allocations of feeding levels on starting weight. Early detection of errors was also possible due to the introduction of daily reports to monitor the pigs and the feeder functioning. Once these recommendations and reports were put in place, another data set was collected and the analysis re-run. The results of the second analysis showed that the changes made reduced the effect of the factors causing a reduction in feed intake, mainly the NVWEEK, week and start weight. The changes also reduced the number of pigs eating above the allowance and increased the number of pigs eating close to the allowance allocated.
By identifying and rectifying errors in the individual feed intake data that could have resulted from feeder malfunction, the likelihood that the extreme values found in the data set are not the result of measurement errors is increased. Therefore these extreme values are very useful in selection programs because they are more likely to have a genetic background (de Haer, 1992; Hall, 1997).

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