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The determination of beginning- and end-of-period live weights of growing pigs

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Abstract: Optimisation of meat production systems depends upon accurate performance assessment. Weigh platforms in electronic feeding stations allow continuous monitoring of individual pig weight change. Such a system was compared with a conventional mechanical scale with the general result: feeding station weight (kg) = 1.02 (0.010) scale weight − 1.65 (0.766). As compared with the conventional scale measurement at start and at finish of test, back extrapolation of daily weights collected over time in electronic feeding stations may give an improved estimate of start weight, and forward extrapolation an improved estimate of final weight. Regression predictions suggest this to be the case for final weight, but for start weight both systems are open to error due to variation in weight in the early days of test. However, such variation (and its diagnostic utility) is only observable with a system that continuously monitors weight.

Keywords: pig weight; automatic weighing

INTRODUCTION

Good commercial practice, and the nutritional and genetic research that underpins it, requires the accurate monitoring of the performance of growing pigs. Fundamental to this process is the determination of live weight at the beginning and at the end of the grow-out period. As the economic efficiency of conversion of pig food to pig meat is sensitive to small changes in rates of live weight gain, the monitoring procedure is sensitive to the precision with which start and end weights are determined.

Data from automatic weigh stations are becoming increasingly used in research to estimate animal live weight, and may come to serve commercial production systems as a means of non-invasive semi-continuous performance monitoring. Current commercial practice is to weigh a pig once, if at all, on a conventional scale and take this single result as absolute. Replication reduces the error associated with variation in animal weight within the same day due to gut fill and excretion pattern, but replication by repeat manual weighting is a non-trivial and stressful event for both human and animal. However, an automatic weighing system placed in an electronic feeding station provides a convenient point of interaction, and also of pig identification.

Presently available automatic weighing systems include forelegs weighing[1] where a platform accommodates the front legs of the pig only, whole animal weighing where all four legs are located on the platform, and video image.[2,3] With forelegs weighing, the body weight is estimated with an assumed part/whole relationship that could be a cause of error, but the balance mechanism occupies less space than with the whole animal system. In the case reported here, a whole animal weighing system was used, sited in the electronic feed station such that the animal stood with all four legs upon the platform in order to access the feed trough. Problems with this system can include the presence of more than one pig on the balance during weighing, movement by the pig on the balance plate, and excrement or other foreign material on or under the balance. All weighing mechanisms can be subject to continuous or intermittent mechanical problems.

The objective of the reported analysis is, by examining the relationships between them, to investigate two methods of determining the start and end weights of growing pigs. The first method is the

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standard procedure whereby a single value for the weight of an individual pig is determined by a single weighing with a conventional 'manual' weigher. The alternative procedure now introduced is the determination of a single value for the weight of an individual pig by extrapolation of automatic (non-invasive) multiple measurements taken over the previous (for end weight) or subsequent (for start weight) 14 days.

MATERIALS AND METHODS

The conventional manual scale weigher used was an Avery system with a mechanical linkage suspending the platform from an electronic weigh head, giving pig weights stated to be accurate to within 2%. The scale was calibrated with weights at the start of the trial. The automatic feeding station balance was fitted as an integral part of the electronic feeding station (FIRE® feeder) placed in each pen. This system weighs pigs each time they use the feeder, and the median is taken as the single weight for the day, which sifts aberrant values. The load platform under the race is suspended from a load cell using the patented Osborne ACCU-ARM® weigh scale mechanism, and stated to be accurate to within 2%. The load cells were calibrated using the standard FIRE software package and calibration weights. The weights measured using the conventional manual Avery mechanical scale are reported as scale weight (SW), and those measured automatically from the feeders as feeding station weight (FSW). Each of the six pens was fitted with an integrated automatic feeder/weigh platform; feeder and pen effects are therefore confounded. The relationship between conventional and automatic systems could be different for the six machines used. Results for each feeder (pen) are reported separately.

The first part of this report refers to pigs weighed using the conventional manual weigh scale (SW) when the animals were removed at the end of the trial. Comparable weights were obtained from the (single) last-day value from the load cell data from the automatic feeding station system (FSW). One hundred and four individual animals were available, from which four were removed as the differences between same-day values for the two systems exceeded 10 kg. The data set thus comprised 100 comparative values.

The second part of this report determines if the automatic feeding station system gives an acceptable measure of animal weight at the start and at the end of the experiment. This was done by comparison of the single value determined by the conventional scale at the beginning and at the end of the trial period (SW) with a weight estimated by extrapolation from the daily stream of automatic feeding station weights (EW). There were six pens and six feeding stations (one per pen), enabling 104 animals to be observed. Best commercial practice was followed for the placement of pigs into pen groups. Namely, groups were made up of subsets of 'familiars' that had previously been penned together. However, the act of placing pigs into new subsets and pens is recognised as potentially disruptive of growth performance. Weight at start (measured as SW) was 27.1 (SD 3.24) kg. Animals were removed from the trial serially at weights of 31.8 (3.59), 41.9 (7.77), 63.1 (4.09), 82.0 (9.73) and 113.7 (11.32) kg. For EW, animal weight was estimated by simple regression of weight on time for each individual pig, using the first 14 days (for start weights) or the last 14 days (for end weights) and extrapolating backwards (for start weights) or forwards (for end weights) to the intercept for the date at which the scale weight was recorded. For each pig, two pairs of records were thus obtained: for start weight, SW from the conventional manual scale at the start of the trial, and the estimated weight (EW_{start}) determined by back extrapolation of weights from the automatic feeding station system at the start of the trial; for end weight, SW from the conventional manual scale at the end of the trial, and the estimated weight (EW_{end}) determined by forward extrapolation of weights from the automatic feeding station system at the end of the trial.

RESULTS

In relation to the first part of the trial, pigs averaged 67.7 (SD 33.9) kg, ranging from 25 to 143 kg. Regression of automatic feeding station weight (FSW) on manual scale weight (SW) gave

$$\text{FSW} = 1.02\ (\pm 0.010)\ \text{SW} - 1.65\ (\pm 0.766)$$

$$(\pm 3.41) \quad n = 100$$

The values in parentheses are the standard errors for the coefficient and for the constant, and the overall standard error of the estimate.

The coefficient was not significantly different from unity. The constant was significantly different from zero ($P = 0.03$).

In relation to the second part of the trial, examples of the relationships between estimated weight (EW) and scale weight (SW) are presented in Figs 1 and 2. In Fig 1, relating to start weight, the data were relatively

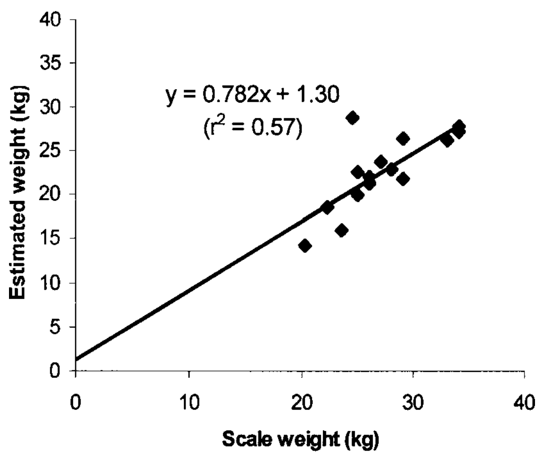

Figure 1. Estimated start weight from automatic feeding station system against conventional manual scale start weight in Feeder 4.

variable, whilst in Fig 2, relating to end weight, the data had low variation. The slopes and intercepts were close to the hypothetical values of 1 and 0 respectively.

Results were as follows (standard errors are given in parentheses for the coefficients and the constants; each equation is followed by a statement of the standard error of the estimate, or RSD). The presence of an asterisk indicates that the slope or the intercept was significantly ($P < 0.05$) different from 1 or from 0 respectively. A purpose of the study was to test, against the conventional method, the veracity of the determination of the start and end weights by extrapolation using the automatically collected FIRE feeder data. It is therefore hypothesised that the scale weight is measured 'without error', and it is thus used as the independent variable in the regression equations.

$$\text{Feeder 1. } EW_{start}(kg) = 0.610\ (\pm 0.315)\ SW + 8.61\ (\pm 8.58)\quad (\pm 4.06)\quad n = 22$$

$$\text{Feeder 2. } EW_{start}(kg) = 1.356\ (\pm 0.280)\ SW - 12.7\ (\pm 7.89)\quad (\pm 2.33)\quad n = 15$$

$$\text{Feeder 3. } EW_{start}(kg) = 0.622\ (\pm 0.202)\ SW + 7.22\ (\pm 5.29)\quad (\pm 2.95)\quad n = 21$$

$$\text{Feeder 4. } EW_{start}(kg) = 0.783\ (\pm 0.174)\ SW + 1.30\ (\pm 4.76)\quad (\pm 2.71)\quad n = 17$$

$$\text{Feeder 7. } EW_{start}(kg) = 1.678\ (\pm 0.347)\ SW - 19.8\ (\pm 9.43)^{*}\quad (\pm 5.11)\quad n = 22$$

$$\text{Feeder 8. } EW_{start}(kg) = 0.632\ (\pm 0.191)\ SW + 0.47\ (\pm 5.30)\quad (\pm 3.02)\quad n = 17$$

$$\text{Feeder 1. } EW_{end}(kg) = 1.010\ (\pm 0.021)\ SW + 1.09\ (\pm 1.30)\quad (\pm 3.07)\quad n = 20$$

$$\text{Feeder 2. } EW_{end}(kg) = 1.035\ (\pm 0.018)\ SW - 2.67\ (\pm 1.52)\quad (\pm 1.28)\quad n = 14$$

$$\text{Feeder 3. } EW_{end}(kg) = 1.025\ (\pm 0.018)\ SW - 2.89\ (\pm 1.29)^{*}\quad (\pm 3.13)\quad n = 19$$

$$\text{Feeder 4. } EW_{end}(kg) = 0.991\ (\pm 0.026)\ SW + 2.03\ (\pm 2.35)\quad (\pm 2.52)\quad n = 16$$

$$\text{Feeder 7. } EW_{end}(kg) = 0.945\ (\pm 0.023)\ SW^{*} - 2.02\ (\pm 1.53)\quad (\pm 3.71)\quad n = 20$$

$$\text{Feeder 8. } EW_{end}(kg) = 0.897\ (\pm 0.038)\ SW^{*} + 9.89\ (\pm 3.37)^{*}\quad (\pm 3.54)\quad n = 15$$

Systematic differences between manual scale weights (SW) and weights estimated by extrapolation from the continuously collected data from the automatic feeding stations (EW) were not evident. The relationship between EW_{start} and SW at start was prone to a high degree of variation. Absolute values for the slope and the intercept were usually different from the respective hypothesised values of 1 and 0, but significance was not attained owing to the high standard errors. The relationship between EW_{end} and SW at end was characterised by low variation. Absolute values for the slope and the intercept were usually rather close to the respective hypothesised values of 1 and 0, although Feeder 8 performed noticeably differently to the others.

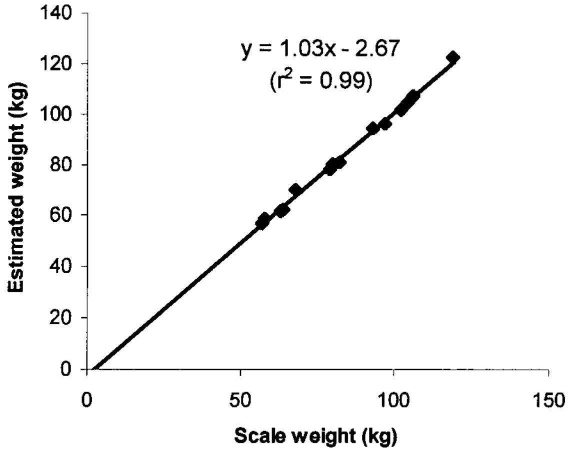

Figure 2. Estimated end weight from automatic feeding station system against conventional manual scale end weight in Feeder 2.

DISCUSSION

In the first part of the trial the solution of the regression equation for values of pig live weight yielded estimates that might be considered as within expectation of that for two weighings undertaken for a single pig with the same machine at two different times of day. However, the presence of a systematic error may be inferred from a significant constant, although the constant was small in absolute terms.

In the second part of the trial the relationships between estimated weight (EW) by automatic feeding station system and scale weight (SW) by conventional manual system for each of the six pen replicates are presented separately. Separate presentation allows observation of any between pen (between feeder) effects. Feeder 8 had a lesser slope, a greater constant and more variation. This may have been a result of fluctuations in the automatic operation of the system not picked up by calibration, or particularities in the behaviour of that particular group of pigs. This result is deserving of closer investigation as to its cause.

It may be suggested that, on account of the variation, prediction of the start weight of individual pigs by back extrapolation of weights obtained from automatic collection during the first 14 days would be imprudent. On the other hand, the error-prone nature of back extrapolation was the result of variation in live weight as was determined during the course of the first 14 days of the trial. This was indicated by the high standard errors associated with the equations relating EW_{start} to SW, and Fig 1, as compared with equations for EW_{end} and Fig 2. Reduction in growth and inconsistency of liveweight gain in the period following the regrouping and movement of pigs are common, and a cause of loss of accuracy in the measurement of both commercial and experimental performance.[4–6] The back extrapolation may therefore be a better value for purposes of monitoring subsequent performance than the 'absolute' value, which may be followed by a period of live weight loss or erratic live weight gain at the beginning of the measuring period.

It would appear somewhat safe to obtain end weights by forward extrapolation, although there were four significant parameter values.

From the aspect of the reporting of data 'as found', it is concluded that conventional manual scale weights may be an adequate basis of analyses for responses over time and weight intervals, but the daily records of weight from automatic weighing systems may be more appropriate and informative. The results presented here suggest that weights from the extrapolation of data provided by the automatic feeding station system may be used with confidence. The failures, such as existed, of the extrapolation methodology to predict conventional start and end weights is a reflection upon variation in pig weight (particularly at the start of test) and not upon the accuracy of the weight determined. Although the scale weight (SW) at the start of a trial period is undeniably the 'true' weight at that instant, it would be naive to presume that it was the most useful indicator of the 'start point' of the trial for the pig in question.

As shown here, there is much variation in the weight of animals over the first 14 days of the trial. This phenomenon would not be observed with conventional procedures, but was evident through continuous automated collection of live weight data through the feeding station system. The extent of the variation that appears consequent upon the grouping of animals and their placement into trial accommodation will depend upon (a) management and (b) the time allowed to elapse between placement and effective trial start. In both commercial and experimental circumstances the stress and difficulty of conventional weighing through a manual system mean that the start of the trial (and the weight that pertains thereto) is coincident with grouping and placement. It would be unusual for pigs to be reweighed 14 days after the presumptive start of commercial monitoring or of an applied nutrition or genetic trial.

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