BRIEF COMMUNICATION: Can weighing multiple times increase the accuracy of live weight recording?

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Introduction

The recording of live weight in livestock enterprises is fundamental for breeding and production, the ease of which has been greatly improved with the advent of automated weighing and recording platforms. However, the extent to which significant advances within a livestock enterprise can be made with the utilization of live weight data depends on the validity of the indicated weights which can be influenced by measurement error from a number of sources (Hughes 1976). Thus, the use of scales only provides an estimate of an animal's true live weight. Despite the importance of live weight, there is a distinct paucity of published data surrounding the variation in live weight estimates and weighing protocols that may be used to reduce this variation.

The objectives of this study were to redress this lack of fundamental data by quantifying the variability of a live weight estimate and examining if this can be reduced through both fasting and repeated weight recordings.

Materials and methods

General methodology

The live weight of 100 10-month-old Coopworth ewe hoggets was repeatedly recorded following removal from pasture and 24 hour fasting in the weighing protocol described below. All animals were previously tagged with sheep light-weight electronic radio-frequency identification (RFID) ear tags (Allflex Ltd, Auckland, New Zealand). Live weight was logged using an automated weighing and drafting platform (Prattley Industries Ltd, Temuka, New Zealand) fitted with electronic weigh load bars (Tru-test, Auckland, New Zealand) and a portal electronic tag reader (model No.S03071, Prattley Industries Ltd, Temuka, New Zealand). Animal identification and weights were automatically recorded on a Tru-test XR3000 head unit (Tru-Test Ltd, Auckland, New Zealand).

Weighing protocol

All animals were grazed together on pasture prior to being mustered and yarded at 1200 hours (Time 0 hours). Immediately following yarding the individual live weight of all animals was recorded to give an estimate of their weight at 0 hours with scale sensitivity, the level of scale precision, set to 0.1 kg. Once all 100 animals were weighed they were re-weighed a further two times (runs) with a maximum time between the start of each run of 20 minutes. No effort was made to influence the order in which animals were weighed. Following the third weight for 0 hours being recorded, all animals were maintained in the yard without access to feed or water for 24 hours at which time the multiple weighing procedure described above was repeated. Animals were returned to graze on pasture for approximately one week before the entire process was repeated on two further occasions, each one week apart, using the same 100 animals, giving a total of nine measures of live weight for each individual animal at the start (0 hours) and end of the 24 hour fast (24 hours).

Statistical analysis

As the true live weight of an animal can only be estimated, the mean of the three live weights for each individual at each measurement time was considered to be the best estimate of the true live weight. Within each fasting time, Student t-tests were used to compare the mean of the first weight recorded with the mean of the first two weights recorded, and with the mean of all three weights recorded, using Minitab® (Version 16, Minitab Inc, State College, Pennsylvania, USA). For each individual at each weighing time, the deviation from the best estimate of true live weight, the mean of all three weights, for the first recorded weight and for the mean of the first two recorded weights, was calculated. Probit analysis using GenStat statistical package (Version 13.3) (Payne et al. 2009) was used to determine the range which encompassed 50, 75, 80, 85, 90, 95 and 99 percent of records compared with the best estimate of live weight for each measurement time. The values for each percentile for each of the three trials were then summarized giving the overall mean and standard error of the mean.

Results and discussion

Live weight of animals is a measure that is widely utilized in both research and commercial settings. While the practicality of recording animal live weight has been vastly improved with the advent of electronic scales and automated weighing platforms, there are still a large number of factors

that may influence the recorded weight of an individual. These include errors associated with both animal movements while on the weighing platform or the weighing apparatus itself. As such, the true live weight of an animal is not known and can only be estimated. With this in mind, the objective of this study was to evaluate the accuracy of weight estimates and whether these can be improved through weighing multiple times. In order to achieve this, a best estimate of the true live weight of each animal is required, being the mean of the three recorded live weights at each sampling time which, in itself, can have significant limitations for the interpretation of results. Overall, the protocol for estimating live weight used had no influence on the mean live weight that was logged, with values ± the standard error of the mean, being 46.0 ± 0.3, 45.9 ± 0.3 and 45.9 ± 0.3 kg at 0 hours fasting and 43.1 ± 0.3, 43.1 ± 0.3 and 43.0 ± 0.3 kg after 24 hours fasting for the first weight, the mean of the first two weights and the mean of all three weights, respectively (P >0.8 for all combinations). As such, the approach of using the mean of the three weights as the best estimate of their true live weight can be considered a reasonable starting point for examination of the variability associated with recording the live weight of animals.

The range in weight recordings, relative to the best estimate of live weight, for which a given percentage of the population will fall within if just the first weight or the mean of the first two weights are considered in animals after 0 hours or 24 hours fasting, is given in Table 1. Across all scenarios, the minimum sensitivity at which a reliable weight can be estimated increases with an increasing proportion of accurate weight recordings. For example, measurements using the first recorded weight only at 0 hours fasting, 50% of individuals were within 0.1 kg of their estimated true weight while 99% of the weight recordings at the same time were within 0.7 kg. In comparison, for animals that were fasted for 24 hours, this variation was reduced with 99% of animals recording a first weight that was within

0.4 kg of their estimated true weight. Nearly all of this variation can be explained by a slight decline in mean live weight between the first weighing and third weighing by 0.2 kg (0.51%) and 0.1 kg (0.15%) at times 0 hours and 24 hours, respectively. This presumably reflects either reduced losses of excrement and/or evaporative losses in fasted animals between weight recordings. It is possible that reduced variation due to less animal movement as they became familiar with the weighing protocol may be a contributing factor.

Including the mean of the first two weights improved the accuracy of weight recordings compared with a single weight with 99% of weight records using the mean of the first two weights being within 0.3 kg and 0.2 kg of the estimated true weight for 0 hours and 24 hours fasting, respectively. This was anticipated due to the method used to determine the estimated true weight of an individual. As such, it is difficult to determine the real advantage in weighing accuracy from weighing multiple times. Direct comparisons of multiple weighing within an immediate timeframe, as carried out in this study, are not available from the literature. However, similar conclusions were reached by Lush and Black (1927) who reported reduced error in live weight recordings in cattle that were weighed on three consecutive days. In contrast, Bean (1946) observed the use of a three-day mean weight in swine actually introduced further error into the results rather than ruling it out. Similarly, Bean (1948) reported that a single weight in sheep was as reliable as the average of three consecutive daily weights, a conclusion supported by Baker et al. (1947) in calves when uniform conditions were maintained. Although the results of the current study indicate that multiple weight recordings did increase the accuracy of weight estimates, the additional effort required must be considered against the relative reward. The taking of multiple measurements in the interests of completeness, itself not achievable, involves the law of diminishing returns for new information from each additional unit

Table 1: Variation in live weight ± standard error of the mean (kg) from the best estimate of the true live weight of an animal, derived as the mean of three weighings, required to include a given percentage ranging from 50% to 99% of the population for when the first recorded weight alone is used, or the mean of the first two weights for animals that have been fasted for 0 hours or 24 hours. Mean true live weights were estimated to be 45.9 ± 0.3 kg and 43.0 ± 0.3 kg at 0 hours and 24 hours fasting, respectively.

Proportion of samples (%)	0 hours fasted		24 hours fasted	
	1st weight	1st and 2nd weight	1st weight	1st and 2nd weight
50	0.08 ± 0.07	0.01 ± 0.10	0.08 ± 0.01	0.04 ± 0.02
75	0.26 ± 0.08	0.09 ± 0.06	0.18 ± 0.01	0.09 ± 0.01
80	0.30 ± 0.09	0.12 ± 0.06	0.21 ± 0.01	0.10 ± 0.01
85	0.35 ± 0.10	0.14 ± 0.05	0.24 ± 0.01	0.12 ± 0.02
90	0.42 ± 0.11	0.18 ± 0.05	0.27 ± 0.01	0.13 ± 0.02
95	0.52 ± 0.12	0.22 ± 0.05	0.33 ± 0.01	0.16 ± 0.03
99	0.69 ± 0.16	0.31 ± 0.09	0.43 ± 0.02	0.22 ± 0.06

of time and money spent collecting and analyzing the data (Lush & Copeland 1930). Given that an acceptable level of variation in live weight records is considered to be ±1% (Lush et al. 1928), 93% of the first weight records at 0 hours fasting and 100% of first weight records after 24 hours fasting, were within this limit. As such there appears to be little practical advantage in weighing more than once to improve the precision of estimated live weight, especially for fasted animals. With this in mind, there are numerous potential sources of error when obtaining a weight measurement, which include both the animal and the weighing apparatus. It remains to be determined what, if any, benefit there may be from multiple weighing of animals of different size from those used here and/or with different weighing apparatus.

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