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An automated walk-over weighing system as a tool for measuring liveweight change in lactating dairy cows

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ABSTRACT

Automated walk-over weighing systems can be used to monitor liveweights of cattle. Minimal literature exists to describe agreement between automated and static scales, and no known studies describe repeatability when used for daily measurements of dairy cows. This study establishes the repeatability of an automated walk-over cattle-weighing system, and agreement with static electronic scales, when used in a commercial dairy herd to weigh lactating cows. Forty-six lactating dairy cows from a seasonal calving, pasture-based dairy herd in southwest Victoria, Australia, were weighed once using a set of static scales and repeatedly using an automated walk-over weighing system at the exit of a rotary dairy. Substantial agreement was observed between the automated and static scales when assessed using Lin's concordance correlation coefficient. Weights measured by the automated walkover scales were within 5% of those measured by the static scales in 96% of weighings. Bland and Altman's 95% limits of agreement were −23.3 to 43.6 kg, a range of 66.9 kg. The 95% repeatability coefficient for automated weighings was 46.3 kg. Removal of a single outlier from the data set increased Lin's concordance coefficient, narrowed Bland and Altman's 95% limits of agreement to a range of 32.5 kg, and reduced the 95% repeatability coefficient to 18.7 kg. Cow misbehavior during walk-over weighing accounted for many of the larger weight discrepancies. The automated walk-over weighing system showed substantial agreement with the static scales when assessed using Lin's concordance correlation coefficient. This contrasted with limited agreement when assessed using Bland and Altman's method, largely due to poor repeatability. This suggests the automated weighing system is inadequate for detecting small liveweight differences in individual cows based on comparisons of single weights. Misbehaviors and other factors can result in the recording of spurious values on walk-over scales. Excluding outlier weights and comparing means of 7 consecutive daily weights may improve agreement sufficiently to allow meaningful assessment of small short-term changes in automated weights in individuals and groups of cows.
Key words: dairy, cattle, weight, scale

INTRODUCTION

Australian dairy cows commonly have radio frequency identification (**RFID**) microchip ear tags that allow identification using a microchip reader. The use of RFID has led to the development of a multitude of on-farm dairy infrastructure systems based on identifying cows as they walk into or out of the dairy. Such systems are becoming increasingly common in Australian dairy herds, with typical features including the individual control of feed levels in the dairy and various measurements of milk yield and quality.

Body condition score has been used as a noninvasive tool for assessing the degree of fatness of dairy cows, and repeated BCS assessments have been used to indirectly monitor weight change and energy balance, therefore aiding in the nutrition management of herds (Garnsworthy et al., 2008). Many studies have reported that dairy cattle commonly lose body condition for a period after calving, and the extent of postpartum body condition loss has been associated with reduced fertility (Morton, 2003; Roche et al., 2007b), reduced production (Berry et al., 2007a), occurrence of mastitis (Berry et al., 2007c), uterine infection, metabolic diseases (Roche et al., 2009), dystocia, and stillbirth (Berry et al., 2007b). However, limitations exist for BCS; for example, it is subjective (Maltz, 1997; Maltz et al., 1997), it requires an experienced visual assessor, variation exists between different assessors, and BCS changes only reflect external adipose loss (Macdonald et al., 1999). Whereas BCS assessment is a useful tool, automated weighing technology may provide an objective, more

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sensitive, less labor-intensive method for monitoring liveweight change (Roche et al., 2007a), allowing easier recognition of animals at risk of disease or reduced reproductive performance and improved management at the herd level (Maltz, 1997; Maltz et al., 1997).

Commercially available walk-over scales in combination with RFID technology can identify and record the liveweight of cattle as they traverse a weighing platform and can measure weights of dairy cattle twice daily as they enter or exit the dairy for milking. van Straten et al. (2009) suggested that if automated BW data collection systems were available on farm, BW loss monitoring could be routinely used as a management tool. A paucity of literature exists to describe the accuracy and repeatability of these systems when used in commercial dairy herds. To our knowledge, Alawneh et al. (2011) is the only published study describing the agreement between an automated weighing system and static scales. In that study, weight records from a pasture-fed herd in New Zealand demonstrated excellent agreement with static scales. However, in further studies, biologically implausible outlier weight measurements had to be cleaned to assess the effects of lameness on weight change (Alawneh et al., 2012a) and the effects of weight change on reproductive performance (Alawneh et al., 2012b).

If automated weighing systems are to become an important dairy management tool, it is necessary to understand the agreement of such weighing systems to static scales, and to describe the repeatability and the frequency and etiology of outlier weights. This paper describes the repeatability of an automated walk-over weighing system and the agreement with static electronic scales when used in a commercial dairy herd to weigh lactating cows.

MATERIALS AND METHODS

This study was conducted in Australia on a typical southwest Victorian seasonal-calving dairy herd, where approximately 600 Holstein Friesian and Holstein Friesian × Jersey crossbred cows were milked twice daily in a 50-bale rotary dairy. The dairy had a set of commercially available automated walk-over scales (Tru-test XR3000 WOW Scales, Tru-Test Pty Ltd., Sunnybank, Australia) permanently installed in the exit race of the rotary dairy. All cows in the herd were fitted with RFID ear tags that were read at the exit to the automated scales. As cows traverse the weighing platform, liveweight, cow ID, and time of weighing were automatically recorded by the milking system software (Jantec Systems, Breakwater, Australia).

These walk-over scales were compared with a set of portable electronic static scales on which a weight was not recorded until the animal was stationary (Tru-test AG500, Tru-Test). Prior to the study, both the automated and static scales were calibrated by placing 5 plastic 20-L containers (Redene Iodophor Teat Dip and Spray, DASCO Pty. Ltd., Heidelberg Heights, Australia) on each of the weighing platforms. Each set of scales was initially tared with the empty containers then all containers were filled to the full level with water and calibrated to 100.0 kg.

Forty-six mid-lactation dairy cows (13 first lactation heifers, 10 cows aged 3–5 yr, and 23 cows >5-yr-old) were randomly drafted—every 14th cow in the herd was selected in order of milking—to give a subpopulation of animals with a range of weights (364–696 kg) that was likely to be representative of the main herd. These cows were then loaded onto the rotary milking platform before being weighed while walking over the automated scales. This was repeated 3 times within a 1-h period. Cows were then weighed once while standing still on the static scales. For the purposes of this experiment, the static scales were assumed to measure the true weights.

Each of 3 possible automated weights was compared with the single static weight for the same cow to assess the agreement between the automated and static scales. Repeatability of the automated scales was assessed using each cow's 3 automated weights.

To assess effects of cow behavior, each cow was observed traversing the walk-over weighing platform and any behavior associated with an abnormal crossing was noted and termed misbehavior. Misbehaviors observed during the study and considered to cause spurious readings included fast or frantic passage, another cow on the scale at the same time, or heavy stepping.

Definitions

Definitions for accuracy, agreement, precision, and repeatability are multiple and controversial. To provide clarity for interpretation of findings from statistical tests in this paper, definitions have been provided.

Accuracy is the degree of (systematic) bias (Lin, 2008); when static scale weights are plotted against automated weights, the closeness of the line of best fit to the 45° line (slope of 1) through the intercept; imperfect accuracy can be due to the line of best fit slope deviating from 1 and being shifted upwards or downwards (Lin, 1989). Agreement is the degree to which scores or ratings are identical (Kottner et al., 2011); in this case, the degree to which each automated weight and the static scale weight for the same cow are identical; for continuous data, such as cow weights, it is the combination of accuracy and precision (Lin, 1989). Precision is how far observations deviate from the line of best