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Method to monitor sand level changes in free-stall lying area for dairy cows

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Abstract. Understanding sand properties and proper sand management is critical to the selection and successful use of sand as a dairy bedding material. Use of sand as a bedding material is an alternative solution at many dairy farms instead of straw and other organic materials. In order to successfully use and manage sand as a bedding material for cows, it is necessary to consider monitoring of the sand amount in order to create the highest possible level of lying comfort for animals. The objective of the study was to investigate a modified approach to sand level measurements to find changes in the amount of sand covering the lying area in a barn with the free-stall keeping system. The method to measure sand level changes included use of a timber board (put on the neighbouring partitions at each lying stall) to determine the distance to the bedding surface in two zones of lying stalls. Results of the investigated method of monitoring sand level changes were discussed against the background of other results presented in the specialist literature. The discussion included the problem of measurement accuracy as well as simplicity of the proposed measuring method for practical use by farmers.

Key words: bedding, cow, dairy farm, free-stall, keeping system, management, sand.

INTRODUCTION

Effective management and an appropriate environment are essential for dairy cattle health and welfare (Vasseur et al., 2015). Proper practices and guidance provide dairy farmers with best results concerning care and handling of their cattle.

Cows' comfort is part of animal welfare and may determine efficiency of farm dairy production (von Keyserlingk et al., 2009). Comfort of the cow herd is created in many areas of the barn. The daily time budget for lactating dairy cows indicates that the most important role in the field of comfort is that of the lying area (Gomez & Cook, 2010). Adequate rest has been positively associated with productivity, health and welfare of dairy cattle (Solano et al., 2016).

The percentage of time spent lying by cows shows that it is necessary to create excellent comfort conditions in the lying area to ensure improved cow herd handling. As a result of many experiments, Nordlund & Cook (2003) suggest that the lying surface is a particularly important component of the free-stall design. Such observations were already found in the early eighties, when cow preferences for certain free-stall surface

materials as well as hygiene and lying down behaviour was compared (Natzke et al., 1982).

Certain investigations regarding the lying area for dairy cows emphasize the significance of bedding quality (Fregonesi et al., 2007), amount of bedding (Norring et al., 2010) as well as bedding management resulting in a longer time spent lying down in well bedded stalls in comparison with poorly bedded places (Tucker et al., 2003; Wagner-Storch et al., 2003). Sand and straw beddings influence the lying behaviour, cleanliness, as well as hoof and hock injuries of dairy cows (Norring et al., 2008). Bedding types can be associated with management practices and constitute indicators of milk quality (Rowbotham & Ruegg, 2015). One of the management effects is the amount of bedding used on the stall surface and affecting the cow's response. Drissler et al. (2005) documented how declines in deep-bedded and not maintained stalls with sand as the bedding material can have a dramatic effect on stall usage; lying time declined by about 10 min/d for every 1 cm of reduction in sand bedding. Sand is a popular bedding material used in barns for dairy cows and heifers at the west coast of Canada.

The response of cows to the abovementioned quality of lying surface and quantity of bedding material can be an inspiration for development of methods aimed at assessing changes in the lying conditions of dairy cows. The lying conditions can be identified not only by the stall design (Gaworski et al., 2003) but also by the amount of bedding material. The aim of the paper was to present the research approach (method) for measuring changes in the level of bedding material covering the lying surface for dairy cows kept in the barn with the free-stall system.

It is possible to enumerate certain reasons underlying development of a method for assessing changes in the amount of bedding material consumption. A modified approach to assessment of bedding material for dairy cows can be a source of comparisons with certain known methods for measurement of bedding material changes. Moreover, it can be a source of suggestions to improve management of bedding material in the lying area for dairy cattle and, at the same time, a practical proposition regarding implementation by farmers of a method of bedding material assessment including some simple measurements.

MATERIALS AND METHODS

The measurements concerning changes in the amount of bedding material covering the lying surface for dairy cows were conducted in a free-stall barn located at the University of British Columbia's Dairy Education and Research Centre in Agassiz (British Columbia, Canada) in October 2015. The investigated, naturally ventilated (with curtained sidewalls) wooden frame barn consisted of 288 free stalls divided into smaller units, i.e. pens with 12 stalls each. The lying stalls in each individual pen were configured in 3 rows, 2 rows facing one another and the back row facing a cement wall (Fig. 1). The pens were equipped with stalls divided by Dutch-style partitions (Fig. 2). One stall at each row was bounded by a cement wall.

The laying stalls in the investigated barn were filled with sand.

The laying stalls in the investigated part of barn were refilled with new sand each 18th day. To spread sand on the lying stalls in barn, a spreader attached to the tractor's three point linkage was used.

In order to spread sand in the stalls located in three rows, the tractor with the attached machine (spreader) had to move along two scraper alleys (Fig. 1). During sand spreading, the scrapers were stopped at such a position as to enable the tractor to move along the scraper alleys without any hindrance. At the time of refilling sand at the stalls, the cows were separated in each pen using the chains closing a part of the pen.

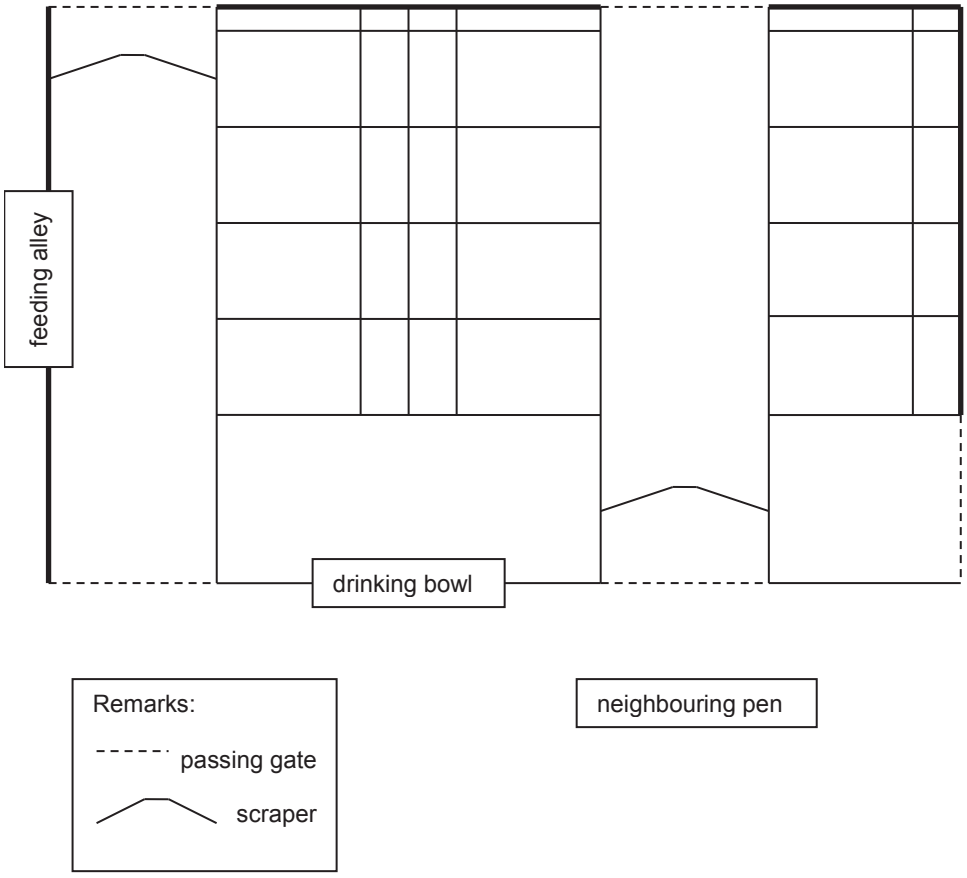

Figure 1. Schema of the pen with lying stalls where measurements of sand level were conducted.

For detailed measurements of sand amount changes, only one pen with twelve lying stalls was chosen. The pen was equipped with typical partitions and, additionally, partitions in the stalls bounded by a cement wall.

Changes in the amount of sand covering the lying surface for dairy cows were identified based on the measured sand level. In order to determine changes in sand level, the distance between the timber board and the bedding surface with sand was measured. The timber board was fixed on the neighbouring partitions in the same places (marked for precise location of the board during each measurement). Measurements with the use of the timber board were taken in two zones (parts) of each lying stall. The front zone was the place where the cow had her front legs during standing and lying activity, whereas the rear zone is the place where the cow kept her rear legs during stall occupation (Fig. 2). The bottom edge of the board had 12 reference points, marked each

10 cm along the board. The distance between each reference point and sand (including vertical direction of the measurement) was measured. Including 12 reference points, the working length of the removable timber board was 110 cm, but real length of the board was greater to enable fixing of the board on the partitions. Its size was smaller than width of each lying stall amounting to about 120 cm.

a)  b) 

Figure 2. Measurements of distance between the sand bedding surface and the timber board put on the front part of partitions (a) and rear part of partitions (b).

Measurements of the distance between 12 reference points and the sand level were carried out for each stall. Including two lines of measurements (timber board put in the front and rear part of the partitions), a set of 24 data items was collected for each lying stall. A measuring tape was used to measure the distance between reference points and the sand level on the wall. A typical flexible measuring tape with the function of stiffening to carry out measurements more easily was used. Measurement accuracy was 0.5 cm. A printed version of a respective sheet was prepared to collect data obtained from the measurements at the barn. During the next stage, the data were transferred into an Excel file for further analyses.

Measurements concerning the level of sand covering the lying stalls were conducted within the period of 17 days, one time per day, during evening milking. The pen was occupied by 12 dairy cows taken to the milking parlour two times per day. A group of cows was out of the pen (in the milking parlour) for about half of hour (per milking), which was enough time to carry out necessary measurements in the lying area. Because the typical procedure of stall management includes levelling of the bedding material surface whenever cows are taken to the milking parlour, the same activity (levelling of the bedding material) was conducted after sand level measurements.

Statistical analysis of collected data was conducted using the Statistica v.12 software. Analysis of variance (ANOVA) for changes in the sand level was conducted. The significance level was $\alpha = 0.05$. Results of the experiment on sand level changes were included as a set of independent measurements. Each day, the sand was levelled after measurements, according to general rules concerning sand bedding management. Inter-observer reliability wasn't checked. The experiment was carried out as a pilot study and will be repeated for more stalls and new measuring equipment (measuring laser) to collect data in a more effective way and include inter-observer reliability.

To find the regression function, nonlinear regression with the backward stepwise analysis was used.

RESULTS AND DISCUSSION

To analyse changes in the amount of sand at the lying area, the following days were included: starting day (day one) and research days (16 days). The period of research days was divided into four stages (I–IV). Each stage consisted of 4 days. For each stage, the mean value of sand level was calculated based on data from all stalls, and included as data for comparisons. In order to find changes in the sand level during the investigation period, differences between level of sand on day one and level of sand for each stage were calculated. The calculations were conducted for data concerning the front and rear line of measurements in the stalls. Thanks to this schema of measurements, the differences in sand level for front and rear part of the stalls are presented in Fig. 3 and Fig. 4, respectively.

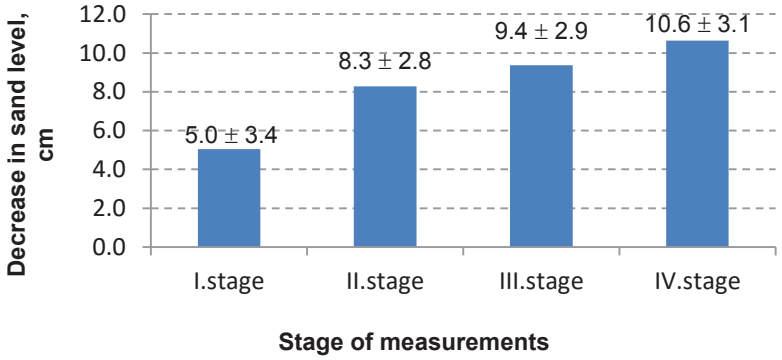

Figure 3. Decrease in level of sand as a bedding material in the front part of measured lying stalls (mean ± SD).

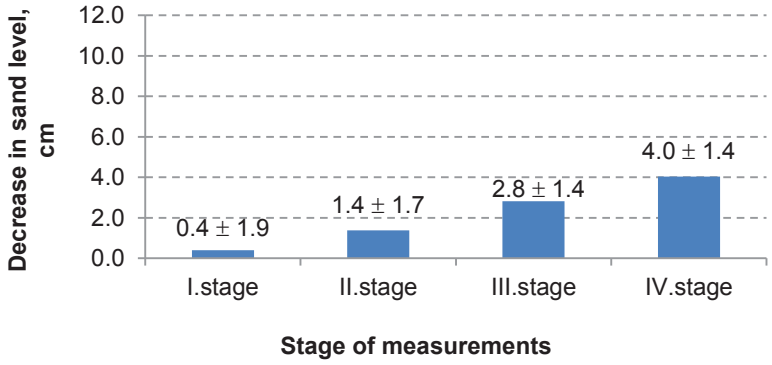

Figure 4. Decrease in level of sand as a bedding material in the rear part of measured lying stalls (mean ± SD).

More details concerning changes in the sand level for the front and rear part of the stalls, i.e. formula of curve and R^2, are given in Table 1.

Table 1. Curve – equation and R^2 concerning decrease in sand level

Part of measured stalls	Curve – equation	R^2
Front	$y = 3.9699\ln(x) + 5.1742$	0.9901
Rear	$y = 0.0602x^2 + 0.9331x - 0.6265$	0.9971

Results of the measurements showed gradual decrease in the level of sand as a bedding material during the research period. Generally, it is possible to observe a difference in dynamics of sand level decrease for two places of measurements, i.e. front and rear part of the stall. The front zone of lying stalls was characterized by a lower level of sand than the rear part of stall during the period of measurements. On the other hand, when data for the first and last stage (I vs. IV) of the measurements are compared, a greater difference (ten times greater) is observed for the rear zone of the stalls than for the front one (the difference: about two times). Of course, one may ask why the decrease in sand level in the front zone of stall is about 2.5 times higher (including comparison of data for the fourth stage of measurements) than the decrease in sand level in the rear zone of the stall. Development of more detailed observations to measure space use by dairy cows when lying down (Ceballos et al., 2004) may be suggested. Moreover, according to own observations during the experiment, persons responsible for taking cows to the milking parlour and levelling the sand bedding showed a tendency to level mainly the rear part of the stalls. To receive the effect of levelling, sand was taken by rake from the middle part of the stall to level the rear zone of the lying stall. Sand in the front part of each stall was also levelled, but without transfer of sand from the middle part of the stall.

Analysing the measurement results, it can be interesting to compare the decrease in sand level observed in the first stage of the experiment. The data concerning the front part of the lying stalls show a considerable decrease in the level of sand (5.0 cm) during the first stage of the measurements. The same trend was noted by Drissler et al. (2005), i.e. loss of bedding depth was greatest on the day after new sand was added. Yet, such trend was confirmed only for the front part of the stall in our experiment, while the rear part of the stall was characterized by only 0.4 cm decrease in sand level during the first stage of the investigation.

The following parameters were included in the analysis of variance: day, stall, row and place of measurements (front and rear part of the stall). The dependent variable in the analysis was the level of sand.

Results of the variance analysis are presented in Table 2.

Table 2. Variance analysis of variance of selected parameters included in the investigation

Effect	SS	df	MS	F	p
Day	1,232.33	15	82.16	5.1236	0.000000
Stall	759.78	11	69.07	4.0316	0.000014
Row	222.85	2	111.43	6.1436	0.002366
Place of measurement	3,655.40	1	3,655.40	401.524	0.000000

Results of the variance analysis showed a significant ($p < 0.05$) difference between the levels of sand for the parameters considered in the investigation. Some results of the statistical analysis are confirmed by observations coming from other experiments. Drissler et al. (2005) indicated that some stalls showed far greater declines than others;

the maximum depths observed on any given days tended to be three times the average depth.

Sand may be removed by the cows digging or by dragging sand out when they exit the stalls, but further research is required to understand how sand leaves the stall (Drissler et al., 2005). Losses of sand used as a bedding material for dairy cows depend on management practices and free-stall construction (Gaworski & Garreth Ferraz Rocha, 2015), but it seems to be important to include other factors to assess quantitative and qualitative changes in the bedding material covering the lying area for cows. These include shape of the bedding surface. Distribution of sand gives the stall surface a concave shape with the maximum depths at the centre and minimum depths near the edges of the free-stall (Drissler et al., 2005).

Management of sand used for bedding in the lying area should ensure the cow's comfort. Thus, it is recommended that at least 4 inches of "workable" sand should be in the stalls at all times (Stowell & Inglis, 2000). The depth of four inches is suggested because cows' legs may tend to sink into fresh sand about 2 to 3 inches. In a typical situation, stalls can be maintained in a good condition by adding fresh bedding every 7–10 days (Stowell & Inglis, 2000). Sand usage rates can range from less than 1 to more than 10 cubic yards per stall per year, with an average of 4.6 cubic yards/stall/year (Stowell & Bickert, 1995). According to own observations, lying stalls with sand as the bedding material are levelled one or two times per day. Most often, sand is levelled each time when cows are taken from the pen to the milking parlour.

The proposed method to monitor sand amount changes in the free-stall lying area for dairy cows includes only two lines of measurements. It seems to be more simple in comparison with the experiment carried out by Drissler et al. (2005), where a grid (120 × 180 cm) was used to measure the distance between the grid and surface of sand covering the lying stall. The aim of the next step can be an investigation to compare the proposed approach to measurements and measurement accuracy with the method where changes in the bedding material level are measured on the basis of more points included in the stall space.

CONCLUSIONS

In order to successfully use and manage sand as a bedding material for cows, it is necessary to consider monitoring of the sand amount in order to create the highest possible level of lying comfort for animals.

Results of the measurements show an expected gradual loss of bedding depth during the research period. Generally, it was possible to observe a difference in the dynamics of decrease in sand level for two places of measurement, i.e. front and rear part of the stall. Loss of bedding depth was greatest on the day after new sand was added in the front part of the stalls.

The proposed method with two lines of sand level measurements can be one step to improve the approach concerning assessment of the lying conditions for dairy cows kept in the free-stall system.

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