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Effect of Stall Base Type on Herd Health, Costs, and Producer Satisfaction

W.K. Fulwider[1], T. Grandin[1], D.J. Garrick[1], T.E. Engle[1], W.D. Lamm[1], N.L. Dalsted[2], B.E. Rollin[1,3]

[1]Department of Animal Science, Colorado State University, Fort Collins
[2]Department of Agriculture and Resource Economics, Colorado State University, Fort Collins
[3]Department of Biomedical Sciences and Department of Philosophy, Colorado State University, Fort Collins

Abstract. The objective of this field study was to compare effect of stall base on herd health, stall maintenance, bedding cost, and producer satisfaction. Ninety-one dairies visited during a 4-mo period starting October 14, 2005 included 33 rubber-filled mattress (RFM), 27 sand, and 31 waterbed (WB) stall bases. In this study, percent culled was higher for RFM (P = 0.001) and sand (P = 0.06) than WB dairies. Percent of cows in fourth lactation or greater was higher on WB than either RFM (P = 0.01) or sand (P = 0.02) dairies. There was no difference between base types for production or somatic cell count. Bedding cost per bed per week was WB ($0.73), RFM ($0.89), and sand ($0.97). Sand beds were bedded less frequently (P = 0.01). Comparisons between RFM and sand indicate higher satisfaction for RFM regarding manure management (P < 0.0001) and higher satisfaction with sand for cow comfort (P < 0.0001). Producers with WB were more satisfied with base life (P < 0.0001) and cow comfort (P < 0.0001) than those with RFM. Producers with WB were more satisfied with cow longevity (P < 0.0001) as compared to RFM. Length of sand stall was correlated with longevity (0.56, P = 0.01) while percent of mature cows was greater on dairies that provided waterbeds (P = 0.02). This data indicates that WB may be a viable option for cows and producers, when good quality sand is unavailable or handling sand-laden manure is not feasible.

Keywords. Bedding requirement, maintenance cost, producer satisfaction, stall base

Introduction

Several different stall bases are currently available to producers (Fulwider and Palmer 2004b). It is important to remember that most bases can be successfully utilized with proper bedding management. The real difference between base types is the effect on cows and base costs over time. There is a difference between stall bases with regard to cushioning ability and how quickly it is lost (Fulwider and Palmer, 2004a; Sonck et al., 2000).

Lesion location (figure 1) differs and prevalence is higher with some base types than others (Fulwider, et al., 2006; Weary and Taszkun, 2000), indicating a need for more bedding, and more frequent bedding.

Preference studies allow cows to choose which bases they prefer lying and standing. Given a choice between rubber-filled mattress (RFM) with different bedding amounts, cows preferred and spent more time lying on RFM with the most bedding material (Tucker and Weary, 2004). Overall, cows preferred foam mattresses and RFM for lying, while waterbeds (WB) were the most preferred base during cold weather (Fulwider and Palmer, 2004b).

Many studies have been conducted regarding bed and bedding type, hygiene and somatic cell count (Manninen et al., 2002; Tucker et al., 2003; Ward, et al., 2002). Reneau et al., (2005) found a stronger relationship between SCC and hind limb hygiene than between SCC and udder hygiene, the strongest relationship was between SCC and udder-hind limb composite score. They also found hygiene score increased with parity. Bewley et al. (2001) reported no difference in milk production or SCC between producers with sand or mattress stalls.

Lesion location differs, and prevalence is higher with some base types than others (Fulwider et al., unpublished; Weary and Taszkun, 2000), which may indicate a need for more bedding and more frequent

bedding. Sogstad et al. (2006) reported cows with tarsal wounds and swellings had more clinical mastitis and teat injuries. Cows with hock and knee swellings move more slowly (Haskell et al., 2006), which provides an additional incentive for producers to prevent these conditions.

Cost per year over the number of years the base is expected to provide comfort needs to be considered. The cost of base maintenance and labor required between different base types must also be considered before committing to a base type. Stall bases have different bedding requirements, therefore bedding availability and cost must be carefully considered before construction begins.

Materials and Methods

Over a 4-mo period beginning October 14, 2005, the first author visited 113 dairies in five states (WI, MN, NY, IA, IN). These herds represented 90,162 cows. One pen of early lactation cows was scored for hygiene, *tarsal* joint and *tuber calcis* lesions on each dairy. Cows were required to have spent the prior year on a specific stall base type to be eligible for the tarsal lesion analysis. Free-stall dairy farm units had a mean of 803 cows, and range from 80 to 4,286. An attempt was made to visit equal numbers of each base type in each state.

Advanced Comfort Technology, Inc., the North American manufacturer of WB provided a list of dairies utilizing WB, and their neighbors who were using other stall base types. Initial contact was made by the first author and an appointment requested within the week. An additional 53 dairies were included in the study as a result of requesting the names of potential participants at equipment dealers, feed mills, university extension offices, veterinary offices and participating producers.

Having a bed or bedding type that did not fit study parameters resulted in only 94 dairies being included in the hygiene analysis. The *tarsal* joint and *tuber calcis* analysis required cows to be on the given base type for a minimum of one year, which resulted in utilization of only 85 dairies. Producers were interviewed with regard to production information, stall dimensions, stocking density, number of cows in fourth lactation or greater, bedding amount, type, and frequency. Sand-stall dairies analyzed had a concrete manure curb. All but five sand-stall dairies utilized new sand, the others re-used (recycled) sand. Data regarding hygiene, lesion incidence, and lesion severity were presented at the 2006 ADSA annual meeting (Fulwider et al., 2006) and are summarized in results and discussion.

Stall dimensions

After all cows from a pen were scored, stall dimensions in their pen were measured. Measurements were taken from two random stalls in both an exterior and interior row. Stall width was measured between stall dividers, behind the neck rail. Stall length was measured from the front of the bed to the rear. If no brisket locator was present, the measurement was taken from the exterior wall, curb, or in the event of head to head stalls, the measurement taken was curb to curb. In the case of sand stalls, the stall length was measured the same way, but curb dimension was also recorded. Neck rail height was measured from the stall base to the under side of the neck rail. Sand stall neck rail measurement was taken from the bottom of the brisket locator to the underside of the neck rail.

Leg lesion measurements

Five areas including the lateral and medial *tarsal* joint and the lateral, medial, and dorsal, *tuber calcis* were scored for skin lesions on a 4-point scale. Cows with no hair loss were assigned a score of 0, hair loss = 1, swelling = 2, severe swelling = 3. Hair loss patches were 1.8-cm in diameter or greater. Swellings assigned score 2 were 7.4-cm or less in diameter, while score 3 swellings were larger and may have been purulent, extensive, or bleeding. Knees were scored whenever possible without interrupting cow flow in the parlor. All injuries were recorded.

Cow hygiene measurements

Every cow in the selected pen was assigned a hygiene score between 1 and 5, with 1 being a very clean cow and 5 very soiled. Score 1 was assigned to cows with no dried manure or manure stains. Cows with manure stains and no dried manure were assigned score 2. Cows with wet or dried manure on the legs and udder were assigned score 3. Extremely soiled cows were assigned score 4, while score 5 was reserved for cows with both manure and manure stains on legs, udders, and ventral abdomen.

Production information

Data were collected during interview regarding milk, fat, and protein production, somatic cell count, number of cows in fourth lactation or greater, cull rate, death rate, and number of cows lame on the day of visit.

Producer satisfaction

Satisfaction values were collected on milking systems, restraining systems, and production and animal well-being as affected by stall base. These were scored 1 to 5, with 5 being very satisfied.

Stall base purchase and maintenance costs

Producers reported the amount of time required to bed, fill, and groom stalls per week. Cost and amount of materials used to bed or fill stalls per week was collected, as well as the frequency and amount of bedding or fill. Information regarding frequency of barn cleaning and stall bedding, and bedding type were also collected.

Statistical analysis

Lesion scores were analyzed as percentage of cows per farm with lesions and by specific lesion location. Differences in hygiene levels and percentages, and lesion severity and percentages and producer satisfaction were analyzed with a completely randomized one-way analysis of variance with farm as the experimental unit (SAS 9.1). When there were significant differences between bed types, pair-wise comparisons were compiled using t-tests. Fisher's protected LSD (t-test) was performed to control the error rate for pair-wise comparisons. Pearson correlations were used for comparing hygiene scores, lesion scores, and production measures.

Results and Discussion

***Tarsal* lesions**

Cows maintained on RFM had more score 1 ($P < 0.0001$), 2 ($P < 0.0001$), and 3 ($P < 0.0001$) lesions than cows on sand or WB. There was a difference in lesion location between cows on sand or WB, but not lesion score. Cows on sand were most affected by medial surface *tarsal* joint lesions (4.8%) while WB cows were least affected (2.7%). Cows on sand had fewer lateral *tuber calcis* lesions than cows on WB ($P = 0.03$), while RFM cows fell in between. Sand-bedded cows had more dorsal lesions ($P < 0.0001$) than cows on RFM or WB. This was likely due to abrasion with the concrete manure curb in deep bed stalls. Sand-bedded cows more often had medial *tuber calcis* lesions (20%) than RFM (13%), or WB (18%).

Knee and thigh lesions

Hairless knees were observed on all three stall base types. The two dairies with the highest percentage of injury (hairless: 42%, 32%; swollen: 2%, 5%) kept cows on RFM. Recycled sand dairies had more ($P = 0.04$) hairless knees (61% of cows on the most affected dairy) than those using new sand. Waterbed dairies with the most knee lesions (hairless: 8%, 3%; swollen: 7%, 1%)

Cows on RFM had bloody abrasions on thighs on 37% of dairies surveyed. The two RFM dairies with the most thigh abrasions had 29%, 22%, 13%, as compared to the worst sand bed dairy (1%) and WB dairy (4%).

Herd characteristics

Ninety-one herds were included in this analysis. Dairies with sand beds tended to have larger herds and the highest stocking density, although there was no significant difference between base types for herd size, stocking density, or stall rows in the barn (Table 1). Stocking density ranged from 99 cows per 100 stalls for RFM to 107 cows per 100 stalls in sand barns. Sand barns were more likely to be 4-row barns than RFM or WB barns.

Table 1. Total herd cow numbers, stocking density, and by bed type.

Stall base type	Number of herds	Average herd size	Standard deviation	Cows scored	Stocking density	SEM	Stall rows per barn
[1]RFM	33	905.7	1936.6	3,971	99.4	0.03	4.7
Sand	27	1098.5	1149.6	3,854	107.0	0.04	4.3
[2]WB	31	467.1	467.1	2,725	102.8	0.03	4.6

[1]Rubber-filled mattress
[2]Waterbed

Stall dimensions: lameness, lesions, somatic cell count,

The greatest difference was between RFM and sand stalls ($P = 0.11$) for stall length and width (Table 2). Sand stall length may be misleading as the concrete manure curb added 7.6-cm to 27.9-cm to the length of these beds. Sand stalls and RFM also had the greatest difference for neck rail height (Table 2), with sand at 116.3-cm and RFM at 118.6-cm. Somatic cell count was correlated with stall width (-0.50) in RFM barns ($P = 0.01$), and with stall length (-0.46, $P = 0.01$).

Table 2. Stall width, length, and neck rail height by bed type.

Stall bed type	Stall width	SEM	Stall length	SEM	Neck rail height	SEM
[1]RFM	46.4	0.3	67.8	1.2	46.7	0.5
Sand	45.6	0.4	70.8	1.5	45.8	0.5
[2]WB	46.0	0.3	70.0	1.3	46.0	0.5

[1]Rubber-filled mattress
[2]Waterbed

In sand barns, stall length was correlated with percent mature cows (0.56, $P = 0.01$). This may be due to there being enough room to prevent abrasion as her leg is entirely on the bed. Stall length was correlated with percent of cows with score 2 lesions or swellings (-0.23, $P = 0.04$), across all stalls. When stalls are too short, cows may be more likely to abrade legs on the curb. For RFM, percent of lesion 1-affected cows was correlated with stall length (-0. 37, $P = 0.07$), which is very similar to the sand correlation with stall length (-0. 38, $P = 0.08$). Percentage of cows with lesion score 3 was correlated with stall width (-0.52, $P = 0.01$). Narrow stalls may not give cows the opportunity to change position.

Table 3. Times manure is removed per day; percent culled and died annually, and reported lame on visit day.

Stall bed type	Times manure removed / day	Percent culled	Percent died	Percent lame
[1]RFM	3.4^{x}	29.4^{a}	6.1	2.1
Sand	2.5^{y}	25.5	5.9	2.2
[2]WB	2.4^{y}	22.8^{b}	6.6	2.4

Means with different superscripts within column differ.
[ab]$P = 0.001$
[xy]$P = 0.05$.
[1]Rubber-filled mattress
[2]Waterbed

Percentage of cows reported lame on farms on the day of visit (Table 3) was correlated with SCC (0.45, $P < 0.0001$) and neck rail height (-0.22, $P = 0.05$) across all base types. Lame cows and SCC appear to increase together, this may provide an additional incentive to prevent lameness. Increasing neck rail height may be an effective way to reduce lameness, especially if cows are observed standing half-in-and-out of stalls. The percent of cows reported lame was correlated (-0.38) with stall length on RFM dairies ($P = 0.04$), and SCC (0.52, $P = 0.002$). Percentage of lame cows is correlated with SCC for sand cows at 0.45 ($P = 0.02$). In sand barns, percent lame cows was correlated with times per day manure was removed (-0.45, $P = 0.03$), perhaps indicating a need to increase manure removal frequency. Manure was removed more frequently from RFM barns than either sand or WB dairies ($P = 0.05$). Annual culling rate was higher for RFM than WB dairies ($P = 0.001$), while sand dairies fell in between. There was no difference between base types for percent lame or annual death rate.

Cow hygiene

Cows maintained on RFM or WB had better hygiene than those maintained on sand ($P < 0.0001$). In this study, this was primarily due to sand-manure spatter clinging to cows lower legs. Producers with RFM or WB bedded cows more frequently ($P = 0.02$) at 3.9 times per week, while sand dairies filled stalls 1.9 times per week (Table 3). Frequent bedding keeps stalls dry as well as providing constant level of "lubrication" between the cow and the bed. When sand stalls are not filled regularly, the cow may not experience the level of comfort required for maximum comfort and production. Dairies with RFM cleaned barns more frequently (3.4 times) per day than either sand ($P = 0.05$) or WB dairies ($P = 0.04$). Somatic cell count did not differ by bed type. Hygiene score was correlated with neck rail height for RFM (-0.52, $P = 0.003$) and WB (-0.40, $P = 0.03$), but not sand. Therefore, producers must be mindful of finding the right neck rail height for the cows in their herd, to maximize hygiene and minimize lameness.

Table 4. Percent mature cows, [1]SCC, times bedded per week, and bedding cost per week by bed type.

Stall base type	[2]Percent mature cows	SEM	SCC	SEM	Times bedded/ week	SEM	Bedding cost ($/bed/week)	SEM
[3]RFM	13.3[b]	1.5	241.4	14.5	3.9[a]	0.5	0.89	0.1
Sand	13.5[d]	1.6	235.2	16.1	1.9[b]	0.6	0.97	0.1
[4]WB	19.8[ac]	1.8	232.0	15.2	3.9[a]	0.6	0.73	0.1

Means with different superscripts within column differ.
[ab]$P = 0.01$, [cd]$P = 0.02$, [1]Somatic cell count, [2]Fourth lactation or greater, [3]Rubber-filled mattress, [4]Waterbed

There were more mature cows, defined as being in fourth lactation or greater, on WB dairies than RFM ($P = 0.01$), or sand ($P = 0.02$) (Table 4). This could be highly beneficial to producers looking to increase cow numbers, or for those wishing to increase income by selling dairy replacements.
Percentage of cows with lesion score 3 was correlated with SCC on RFM (0.60, $P = 0.001$). Lesions were more prevalent and more serious on RFM dairies. Since SCC appears to increase with swelling-type lesions, this may provide incentive to for those producers with high lesion counts to adjust management. There was no difference for SCC among base types. Waterbed and RFM dairies bedded more frequently than sand dairies ($P = 0.01$), although sand dairies had higher bedding costs.

Producer satisfaction

Table 5. Producer satisfaction score with cow longevity, lameness, hock injury, teat injury, mastitis, [1]SCC, udder health, and hygiene. 5 = most satisfied, 1 = least satisfied

Stall base type	Cow longevity	Lame	Hock injury	Teat injury	Mastitis	[1]SCC	Udder health	Hygiene
[2]RFM	3.5[by]	3.8[l]	3.8[b]	4.1	3.8	3.9	4.3	4.4
Sand	4.1[x]	4.0[s]	4.8[a]	4.5	3.9	3.8	4.5	4.5
[3]WB	4.5[a]	4.5[kr]	4.7[a]	4.3	3.9	4.1	4.5	4.3

Means with different superscripts within column differ.
[ab]$P < 0.0001$, [kl]$P = 0.001$, [rs]$P = 0.05$, [xy]$P = 0.01$, [1]Somatic cell count, [2]Rubber-filled mattress, [3]Waterbed

Producers who provided WB for their cows were more satisfied with cow longevity than those with RFM ($P < 0.0001$) or sand ($P = 0.001$). Waterbed dairymen were also more satisfied with lameness prevalence than RFM ($P = 0.001$) or sand ($P = 0.05$). Producers who provided sand or WB were more satisfied with lameness prevalence than those with RFM ($P < 0.0001$).

Table 6. Producer satisfaction score with cow comfort, bedding cost and use, manure management, maintenance labor, and stall base life. 5 = most satisfied, 1 = least satisfied

Stall bed type	Cow Comfort	Bedding cost and use	Manure management	Labor	Base life
[1]RFM	3.9[hy]	4.0[l]	4.1[a]	3.8[s]	3.6[b]
Sand	4.9[g]	3.7[d]	3.1[b]	3.7[y]	4.0[y]
[2]WB	4.7[x]	4.7[ck]	4.5[a]	4.3[rx]	4.7[ax]

Means with different superscripts within column differ.
[ab]$P < 0.0001$, [cd]$P = 0.003$, [gh]$P = 0.001$, [kl]$P = 0.05$, [rs]$P = 0.03$, [xy]$P = 0.01$, [1]Rubber-filled mattress, [2]Waterbed

Regarding cow comfort (Table 6), producers with sand were more satisfied than those with RFM ($P = 0.05$), as were those who provided WB ($P = 0.01$) for cows. Those who provided WB were more satisfied with bedding use and cost than RFM ($P = 0.05$), or sand ($P = 0.003$) dairies. This may be due to the fact that WB dairies tend to bed frequently and use less bedding, usually sawdust or lime. Satisfaction with manure management was highest for RFM or WB when compared to sand ($P < 0.0001$). Regarding stall

maintenance labor, producers with WB were most satisfied, more than RFM ($P = 0.03$), and more than those with sand ($P = 0.01$). When base life was considered, WB providers were the most satisfied, more than producers with RFM ($P < 0.0001$), and more than those with sand ($P = 0.01$).

Conclusions

All base types can be successfully managed. Producers must be aware of the differences in management required, especially when considering a change in base type. It is imperative producers visit other dairies that are successfully using other types of equipment and technology whether building new, or remodeling old facilities. Stall dimensions must match not only cow size, but be designed with the base type in mind. Perhaps sand stalls should have as much bed length as RFM or WB in addition to the curb, if cow comfort and less *tarsal* joint abrasion are priorities. Reducing lameness and lesions are important not only to increase production and longevity, but to maintain low SCC and maximize profit. This study indicates a relationship between cow longevity and length of sand stall. Dairies with WB have more mature cows than those with other base types. This may be due in part to the waterbed moving with the cow much in the same way that sand does. Producer satisfaction values support the findings of this study. More research needs to be done to determine the reasons for these differences.

Figure 1. Lesion Locatins (From Weary, D.M., and I. Taszkun. 2000).

References

Bewley, J., R.W. Palmer, and D.B. Jackson-Smith. 2001. An overview of experiences of Wisconsin Dairy Farmers who modernized their operations. *J. Dairy Sci.* 84:717-729.

Fulwider, W.K. and R.W. Palmer. 2004a. Use of impact testing to predict softness, cow preference, and hardening over time of stall bases. *J. Dairy Sci.*, 87: 3080-3088.

Fulwider, W.K. and R.W. Palmer. 2004b. Stall usage differences o.f thirteen different free-stall base types. Prof. Anim. Sci., 20(6), 470-482.

Fulwider, W. T. Grandin, D. Lamm, N. Dalsted, D. Garrick, and B. Rollin. 2006. *J. Anim. Sci.* Vol. 84, 1/J. Dairy Sci. Vol. 89, Suppl. 1, p. 411, Abstract.

Manninen, E., A.M. de Passille, J. Rushen, M. Norring, and H. Saloniemi. 2002. Preferences of dairy cows kept in unheated buildings for different kind of cubicle flooring. *Appl. Anim. Behav. Sci.*, 75(4): 281-292.

Reneau, J.K., A.J. Seykora, B.J. Heins, M.I. Endres, Farnsworth, and R.F. Bey. (2005) Association between hygiene scores and somatic cell scores in dairy cattle. *J. Am. Vet. Med. Assoc.* 227, 1297-1301.

Sogstad, Å.M., O. Østerås, and T. Fjeldaas. 2006. Bovine claw and limb disorders related to reproductive performance and production diseases. *J. Dairy Sci.* 89, 2519-2528.

Sonck, B., J. Daelemans, J. Langenakens. 1999. Preference test for free-stall surface material for dairy cows. Pages 1-9 in *Emerging Technologies* for the 21st Century. Am. Soc. Ag. Eng. St. Joseph, MI.

Tucker, C.B., D.M. Weary, and D. Fraser. 2003. Effects of three types of free-stall surfaces on preferences and stall usage by dairy cows. *J. Dairy Sci.* 86: 521-529.

Ward, W.R., J.W. Hughes, W.B. Faull, P.J. Cripps, J.P. Sutherland, J.E. Sutherst. 2002. Observational study of temperature, moisture, pH and bacteria in straw bedding, and faecal consistency, cleanliness and mastitis in cows in four dairy herds. *Vet. Rec.*, 151(7): 199-206.

Weary, D.M., and I. Taszkun. 2000. Hock lesions and free-stall design. *J. Dairy Sci.* 83: 697-702.