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## Interaction of Overcrowding and Feed Restriction

Currently, the dairy industry is experiencing opportunities and challenges related to its economic sustainability. The opportunity comes in the form of a high price per hundredweight, and the challenge comes from the high input costs required for milk production. This combination of factors may suggest to producers that now is the time to overcrowd facilities (to maximize production on a per pen/group/farm basis), feed to a clean bunk (to minimize feed costs) or combine the two. A recent study published in the Journal of Dairy Science from the University of British Columbia, however, suggests that this management approach may have negative consequences.

This study investigated the effects of the following on feeding, social and lying behavior, and productivity:

- 100 percent stocking density (one cow per feed bin) and unrestricted access to a total mixed ration throughout the day.
- 100 percent stocking density and access to a TMR from 6 a.m. to 8 p.m.
- Overcrowded (200 percent stocking density, two cows per feed bin) and unrestricted access to a TMR throughout the day.
- Overcrowded and access to a TMR from 6 a.m. to 8 p.m.

Feeding behavior was assessed by looking at dry matter intake, the number of visits to the feed bin, feeding time and feeding rate (grams of TMR consumed per minute). Lying behavior was assessed by calculating lying time and bouts. Social behavior was evaluated as the number of displacements from a feed bin. Treatments were imposed for seven days, and each group of cows was subjected to each treatment. Behavioral responses were assessed over a full day and the two hours following the morning delivery of TMR.

Stocking density did not affect dry matter intake, but reducing cows' access to feed from 24 to 14 hours decreased daily matter intake by almost 3 pounds per day. During the two hours following feed delivery, both stocking density and time of access altered DMI (higher at 100 percent and with 14 hours of access). Similarly, cows spent more time feeding when housed at 100 percent or with unrestricted access over a 24-hour period, but less time over the initial two hours of feed availability. Again, cows visited the feed bin more frequently when provided unrestricted access to feeding over a 24-hour period but less often immediately after feed delivery. Both overcrowding and restricted access to feed increased the cows' feeding rate, and the response was most severe when the two treatments were combined. Aggression at the feed bins increased in response to both overcrowding and limited access to feed. The treatments had no effect on the cows' daily lying time or milk production.

In summary, limiting access to TMR by either overcrowding or reducing the time it was available altered the feeding behavior of cows. To compensate for the limited access, cows increased their feeding rate and the time they spent feeding following delivery. Both of these strategies are, potentially, detrimental to rumen health by increasing the occurrence of acidosis. Increased aggression at the feed bunk may result in an increased stress response. Milk production was not affected, but this outcome may be due to the limited amount of time that the treatments were administered. In conclusion, overcrowding and feed restriction can have detrimental effects that may limit the productivity and well-being of cows over the longer term.


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For further reading or complete data, refer to the following:


L.K.M. Collings, D.M. Weary, N. Chapinal, and M.A.G. von Keyserlingk. 2011. Temporal feed restriction and overstocking increase competition for feed by dairy cattle. J. Dairy Sci. 94:5480-5486.

## Lameness Alters the Lying Behavior of Lactating Holstein Cows

Reducing the prevalence of lameness is a key challenge for improving the welfare, and, ultimately, the productivity of dairy cows. A study of lameness across North America observed the prevalence of clinic lameness (locomotion scores of 3 or greater on a 5-point scale) to be 30 percent across surveyed farms in California; 55 percent in the northeastern dairy states; and 28 percent in British Columbia. The prevalence of severe lameness (locomotion scores of 4 or greater) was 3.6 percent in California, 5.4 percent in the Northeast and 3.5 percent in British Columbia. However, the prevalence rates of clinical and severe lameness were highly variable in each region. Researchers from two colleges in the United Kingdom conducted more extensive research by evaluating the differences in lying behavior between chronically lame cows and sound cows. Their results were published in Applied Animal Behaviour Science.

Within this study, chronic lameness was defined as a locomotion score of 3 or greater for the three months proceeding the data collection period of the study. However, no cows with a locomotion score of a 4 or 5 were used, so, functionally, chronically lame cows in this study were those with a locomotion score of 3 for the three months before the study and immediately before data collection. To create the control group, cows that consistently scored 1 or 2 for the three months before the study were considered. After balancing for parity and stage of lactation, groups of 16 normal cows (locomotion score equals 1), 21 mildly lame cows (locomotion score equals 2) and 22 moderately lame cows (locomotion score equals 3) were established. Lying behavior was assessed by calculating lying time and bouts for four days using IceTags. Additionally, the diurnal pattern of lying was evaluated by observing differences in behavior during the day (4 a.m. to 4 p.m.), evening (4-11 p.m.) and night (11 p.m. to 4 a.m.).

The moderately lame cows spent two hours longer lying per day (13 hours vs. 11 hours) than the normal or mildly lame cows or, conversely, fewer than two hours standing (12 hours vs. 10 hours). However, this behavior did not result in differences in total activity (approximately one hour per day), the number of lying bouts per day in which cows engaged (approximately 11), or the average (approximately 69 minutes), minimum (approximately seven minutes) and maximum (approximately 170 minutes) duration of lying bouts. The normal cows produced approximately 18 pounds of milk per day more than the moderately lame cows, which tended to spend less time standing during the day than the other two groups. During the evening, the moderately lame cows spent more time lying and less time standing than the other groups. At night, the locomotion score on lying behavior was not affected.

In summary, chronic, moderate lameness decreases the lying time of the cows in the sample relative to normal or mildly lame cows. This finding is consistent with the existing definitions of lameness that group cows together with locomotion scores of 1 or 2 as non lame. This difference was driven by a modification of behavior during the day, which is generally when cows are most often engaged in feeding behavior. It is reasonable to speculate that the level of lameness may have altered feeding behavior as well, which may explain the differences in productivity. Finally, these data suggest that monitoring lying behavior, specifically during the day, may be a method of lameness detection.

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For further reading or complete data, refer to the following:

Blackiea, N., J. Amory, E. Bleach, and J. Scaife. 2011. The effect of lameness on lying behaviour of zero grazed Holstein dairy cattle. Appl. Anim. Behav. Sci. 134:85-91.

## Managing Heat Stress in Dairy Herds

Summer weather planning can be a difficult task during a long winter season. However, it is important to be proactive when dealing with summer heat abatement to reduce the effects of heat stress early on. Heat stress can have a detrimental effect on cow performance, reducing feed intake, milk production, feed efficiency and reproductive performance. Each of these factors directly impacts a dairy's profitability, making management of heat stress imperative. Employing tools to reduce heat stress before its onset can help maintain cow performance.

Researchers from the Institute of Animal Science at the Volcani Center in Israel conducted a research experiment comparing cow performance when cows were exposed to either five or eight cooling sessions per day. Two groups of 21 cows each were assigned to either treatment one (five cooling sessions per day at 4:10 a.m., 10:15 a.m., 12:10 p.m., 5 p.m. and 7:40 p.m.) or treatment two (eight cooling sessions per day at 4:25 a.m., 7 a.m., 10:15 a.m., 12:25 p.m., 3 p.m., 5 p.m., 7:55 p.m. and 11 p.m.) over the course of four weeks. Cows then switched groups, and the experiment was repeated.

Cows were brought to the holding pen for 45 minutes of repeating cooling cycles consisting of 30 seconds of showering and 4.5 minutes of forced ventilation without showering. This cooling technique may be of particular interest to farmers who have a sprinkler cooling system

in the holding pen but no sprinklers above the feed bunk. Further, the cost of a sprinkler addition in the holding pen may be lower compared to sprinkler installation above the feed bunk. The cooling system in the present study contained 30 sprinklers (720 L/h each), three large fans (198.1 cm in diameter; 120,000 m3 of air/h each) and four small fans (50.8 cm in diameter; 8,800 m3 of air/h each). The large fans were located at the back of the holding pen, and the smaller fans were hung at the top throughout the holding pen.

The average ambient temperature during the study was 82.8 plus or minus 2.3 F, whereas the relative humidity was 68.1 plus or minus 3.8 percent. The average temperature-humidity index was 78.4 plus or minus 2.1. Cows begin to experience heat stress at a temperature-humidity index of 68, which was exceeded in the study and easily surpassed in the Southeastern region in the summer. Cow respiration rates and rectal temperatures were lower for cows exposed to eight cooling sessions per day compared to those cooled only five times. Additionally, daily dry matter intake was 4.6 pounds (9.3 percent) higher for cows in the group cooled eight times per day. The reduction in negative heat stress effects experienced by cooling the cows more often may have impacted the cows' nutrient intake. Along with improved dry matter intake, cows ruminated 7.4 percent longer with more frequent cooling and produced an additional 7.7 pounds of milk per day. It is important to note that the improved level of milk production is due to higher levels of DMI and not to increased feeding efficiency. Regardless of cooling strategy, all cows experienced some heat stress.

The researchers expressed some concern about the cooling method used and the frequency of moving cows to the holding pen for cooling. The potential for a reduction in lying time exists for cows cooled more frequently. However, this concern was irrelevant in this study as the two groups spent approximately the same amount of time lying per day. What may be more important is that the percentage of free time spent lying in the freestalls increased with more frequent cooling (52 percent vs. 43.9 percent). This finding suggests that increased comfort results from more frequent cooling. Those cows that cooled less often needed to spend more of their free time standing to dissipate heat.

Frequent cooling of cows can have a beneficial impact on cow comfort and performance. Cows in the current study ate more, produced more milk and rested more when cooled eight times per day compared to five times per day. Therefore, the benefits of the increased cooling superseded those of reduced cow free time. Farmers must judge for themselves if these benefits outweigh the associated costs for their particular farms. They also must consider installation costs along with increased labor, water and electricity costs. Whether farmers choose to employ a new sprinkler cooling system or add additional fans throughout the barn, preparing for hot weather early is the key to maintaining herd performance throughout the hot summer months.

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For further reading or complete data, refer to the following:

Honig, H., J. Miron, H. Lehrer, S. Jackoby, M. Zachut, A. Zinou, Y. Portnick, and U. Moallem. 2012. Performance and welfare of high-yielding dairy cows subjected to 5 or 8 cooling sessions daily under hot and humid climate. J. Dairy Sci 95(7):3736-3742.

Zimbelman, R. B., R. P. Rhoads, M. L. Rhoads, G. C. Duff, L. H. Baumgard, and R. J. Collier. 2009. A re-evaluation of the impact of temperature humidity index (THI) and black globe humidity index (BGHI) on milk production in high producing dairy cows. Pages 158-169 in Proc. Southwest Nutrition and Management Conference, Tempe, AZ. University of Arizona, Tuscan, AZ.

## New Options for Dry Cow Therapies

Mastitis is an animal health concern that every dairy farmer must face. Costs are associated with reduced milk production and quality, reduced reproductive performance, and increased treatment costs. The dry period is a time during which farmers have the best opportunity to cure existing intramammary infections and reduce the incidence of new infections at the time of calving (Eberhart 1986). Therefore, use of dry cow therapy is a critical management tool for mastitis control on the farm.

Researchers at Texas A&M University compared early lactation mastitis incidence for cows receiving either Quartermaster (Pfizer Animal Health Inc., New York, N.Y.) or Spectramast DC (Pfizer Animal Health Inc., New York, N.Y.) medications. Quartermaster's active ingredient is penicillin dihydrostreptomycin and has been used traditionally as dry cow therapy from Pfizer. The drug is recommended to treat and prevent *Streptococcus aureus* infections during the dry period. Quartermaster requires a 42-day milk withdrawal period and a 60-day meat withdrawal period to avoid antibiotic residues. Conversely, Spectramast DC's active ingredient is centiofur hydrochloride and is recommended for treatment of subclinical mastitis caused by *Staphylococcus aureus*, *Streptococcus dysgalactiae* and *Streptococcus uberis* during the dry period. Spectramast DC only requires a 30-day milk withdrawal period and a 16-day meat withdrawal period to avoid antibiotic residues. Farmers who prefer a dry period that is less than 60 days may find the shorter

withdrawal period associated with treatment using Spectramast DC beneficial.

In the Texas A&M University study, 179 cows were assigned to dry cow treatment using Spectramast DC, and 204 cows were assigned to dry cow treatment using Quartermaster. Teats also were infused with Orbeseal (Pfizer Animal Health Inc., New York, N.Y.) after treatment. Researchers collected composite milk samples before antibiotic infusion to test for bacteria populations and somatic cell count. The results of the tests served as a baseline comparison to measures during the subsequent lactation. Milk samples for bacteria populations were collected at the third milking post-calving. Subsequent lactation milk production and somatic cell count were recorded monthly by the National Dairy Herd Information Association.

Mastitis-causing bacteria isolates were reduced from 19.2 percent at dry-off to 12.9 percent post-calving. However, the different treatments did not significantly affect the presence of mastitis-causing bacteria in the milk samples. Cows infected with gram-negative bacteria at dry-off had increased odds of a clinical infection at 30 and 60 days post-calving. Additionally, cows producing less than 21,127 pounds of milk and lactating longer than 463 days during the previous lactation had increased odds of a clinical infection post-calving. However, cows in the Spectramast DC treatment group had reduced odds of a clinical infection at 30 and 60 days post-calving.

The odds of a cow obtaining a subclinical infection within the first 30 days post-calving were increased for cows with a low previous lactation milk yield, a clinical infection within the last 60 days of the previous lactation, or a somatic cell score greater than 4.5 in the previous lactation. Similarly, the odds of a cow obtaining a subclinical infection within the first 60 days post-calving were increased for cows having a clinical infection during the last 60 days of the previous lactation, a high SCS in the previous lactation or a transitional disease, including metritis, ketosis or left displaced abomasum, post-calving. Cows treated with the Spectramast DC treatment had reduced odds of subclinical mastitis within the first 30 and 60 days post-calving.

The present study indicated that the use of Spectramast DC was an effective dry cow therapy and was associated with lower incidence of both subclinical and clinical mastitis during the first 30 and 60 days post-calving compared to Quartermaster. However, other aspects of the previous lactation, such as length, clinical mastitis incidence, milk yield and somatic cell score, also influence the odds of a subclinical or clinical infection. Producers who wish to shorten the dry period length and avoid antibiotic residues may find the use of Spectramast DC to be effective.

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For further reading or complete data, refer to the following:

Eberhart, R. 1986. Management of dry cows to reduce mastitis. J. Dairy Sci. 69(6):1721-1732.

Pinedo, P., C. Fleming, and C. Risco. 2012. Events occurring during the previous lactation, the dry period, and the peripartum as risk factors for early lactation mastitis in cows receiving two different intramammary dry cow therapies. J. Dairy Sci. 95(2):7015-7026.

## The Postpartum Behavior of Cows and Calves Within a Calving Pen

Currently, the general practice on farms is to remove the calf from the cow soon after birth. This management strategy has multiple benefits, including limiting the stress of separation by preventing bonding, limiting the risk of disease transmission (especially Johne's), and increasing the efficiency of milk production. At the same time, there is some concern that this practice may compromise the welfare of the cow and calf. Additionally, several studies indicate that early separation alters the behavior of the calf in the short- (less social with other calves at 6 weeks), medium- (less aggressive interactions as heifers relative to being reared with a foster cow up to 6 months of age), and long-term (reduced maternal behaviors [nursing/licking post-calving]) upon entering the milking herd. Most of these studies focused on a limited time frame following calving (approximately 24 hours).

A recent Danish study published in Applied Animal Behaviour Science evaluated the behavior of both the cow and calf when housed together for the first 12 days following calving. It was predicted that an increased understanding of maternal behavior and the resulting behavior of the calf might suggest some benefits of this altered management approach.

From May 2009 to March 2010, 38 Danish holstein-frisian cows were enrolled in the study. The calving pens were 13-by-15.7-feet, and two identical pens were situated side by side with a small space providing visual and physical contact between the neighboring cows. Pens were bedded with straw, and each offered individual feeders and waterers. A 4-point score of calving difficulty was recorded, with 1 representing "easy with no assistance" and 4 representing "difficult with veterinarian assistance."

- Behaviors of interest for the cow were posture (lying versus standing) and activity (sniffing or licking calf's head or body, grooming with fixture or self, feeding,

drinking, social contact with other cow, or physical contact with other cow).

- Behaviors of interest for the calf were posture (lying [either upright or on side] versus upright [any posture in which the calf's body is supported by all four legs]) and activity (locomotion, play, sniffing or licking cow's head or body, suckling, contact with neighboring cow, or no activity).

Behavior was recorded over six days during the 12 days following calving. Behavior under undisrupted conditions was recorded on days three, seven and 11 relative to calving. Behavioral priorities were tested by removing the cow for three hours on either day four, eight, or 12 and then returning it to the pen.

The cows increased their feeding times during the three days of behavioral recordings. They spent less time sniffing/licking their calves but spent more time sniffing/licking their neighbors. Finally, they spent less time grooming themselves. The calves spent less time lying, more time engaged in social or locomotion play, and more time licking/sniffing their dam and the neighboring cow. The time they spent suckling or the number of suckling bouts did not change during the 11 days of the trial. Other than spending more time sniffing their calf following reintroduction, the three-hour separation had no effect on the behavior of these cows.

These early studies suggest that there are some behavioral differences during the first two weeks following calving when the cow and calf remain together. The long-term benefits of the cow and calf remaining together or ways to incorporate this management strategy into modern dairy production are still unclear. Finally, the potential gains of keeping the cow and calf together are sufficient to merit the stress that will occur when separation does happen or when the changes in management required to facilitate this approach to postpartum cow/calf management are made.

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For further reading or complete data, refer to the following:

Jensen, M. B. 2011. The early behavior of cow and calf in an individual calving pen. Appl. Anim. Behav. Sci. 134:92-99.

## Dehorning Dairy Calves: An Italian Perspective

A study from a group of Italian researchers published in the November issue of the Journal of Dairy Science evaluated the dehorning practices occurring on-farm in the traditional dairy producing areas of Italy and the attitudes of those farmers toward animal pain. Of the 1,500 farms selected for participation in this survey, 639 responded. Of the respondents, the average farm size was 81 cows. The majority of farms (83.3 percent) milked less than 120 cows, with 10.6 percent milking between 121-200 cows and 6.1 percent milking more than 200. The last dairy survey conducted by the U.S. Department of Agriculture in 2007 addressed some of these same variables for dairy farms in the Western and Eastern regions of the United States.

Overall, 80.5 percent of farms conducted dehorning. However, dehorning varied by farm size. Cows within herds of 61 or more cows were seven times more likely to be dehorned than those within herds of less than 60. On farms of less than 30 cows, only 59 percent of farms dehorned. Twenty-five percent of farms dehorned from seven to 21 days after birth; 13 percent dehorned from 22 to 29 days after birth; 32 percent dehorned from 30 to 39 days after birth; and 27 percent dehorned more than 39 days after birth. The age at dehorning was not affected by farm size. A substantial majority of farms (90.6 percent) dehorned using a hot iron, and the remainder used a caustic paste. The main reason for the selected method was practicality/habit. Typically, dehorning was performed by farm personnel (75 percent), except on farms of less than 30 cows. On these farms, cows were six times as likely to be dehorned by the farm's veterinarian. Other farmers (43 percent) were the most common source of training in dehorning followed closely by no one (27 percent) or a veterinarian (26 percent). The majority of farms did not provide any treatment before (86 percent) or after (63 percent) dehorning. Of those providing treatment, a local anesthetic was administered most commonly before dehorning, and antibiotics were used most commonly afterwards.

Most respondents believed that the pain from dehorning lasted either a few minutes (48 percent) or less than six hours (43 percent). The behaviors thought to be associated with this pain were head shaking (45 percent) or loss of appetite (29 percent). Forty-four percent of farmers were willing to pay for analgesia, with 13 percent willing to pay up to 35 cents per calf, 13 percent willing to pay up to 70 cents per calf, and 19 percent willing to pay up to $1.40 per calf. Farm size had no effect on the farmers' willingness to pay for analgesia or the amount that the farmers would be

willing to pay. Only 34 percent of farmers were willing to pay a veterinarian. Farmers with less than 60 cows were two times more likely to be willing to pay for this service.

The approach of dehorning on U.S. dairy farms is somewhat different according to the results of a 2007 USDA survey. The overall percentage of farms dehorning was greater (94 percent), and the percentage of farms dehorning was greater in small farms (less than 100 cows; 97 percent) than large farms (more than 500 cows; 64 percent). Similar to Italian farms, the majority (69 percent) of U.S. farms used a hot iron. Of these farms, 14 percent used some form of pain relief. Using a tube, spoon or gouge was the next most common method of pain relief, and 22 percent of farms used these methods. Typically, calves on U.S. dairy farms were older when dehorned. Heifers dehorned with a hot iron were typically 7 weeks old.

These two surveys indicate that the approach to dehorning across farms in the U.S. and Italy tend to be more similar than different. This conclusion suggests that some of the welfare challenges are universal. The biggest gaps left in the USDA survey were the practices occurring in the Southern region and the farmers' attitudes towards dehorning. Addressing these issues, along with the general theme of pain management, will be critical in countering efforts of activists working against animal agriculture.

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For further reading or complete data, refer to the following:

Gottardo, F., E. Nalon, B. Contiero, S. Normando, P. Dalvit, and G. Cozzi. 2011. The dehorning of dairy calves: Practices and opinions of 639 farmers. J. Dairy Sci. 94:5724-5734.

## Bedding Choices for Healthy Calves

Raising healthy dairy replacements is an integral part of any milking operation. Healthy calves grow better, reach puberty faster and are easier to breed once they reach maturity. One aspect of raising healthy calves is keeping them in a clean, dry and comfortable environment. When designing this environment, it is important to make proper calf bedding choices. A large array of bedding options is available for calves and deciding which is best rests on many factors, including cost, availability, climate, season and housing type.

A 2012 study at the University of British Columbia looked at the effects of bedding quality on the lying behavior of dairy calves. Calves were housed with access to sawdust bedding containing varying levels of moisture as well as bare concrete. The calves in this study almost always chose to lie down on the driest surface available. No calves chose to lie down on the bare concrete, indicating that calves prefer a dry bedded surface. This may be important especially in winter months when evaporative cooling may lead to increased cold stress.

A 2004 study examined the growth and health of calves housed in individual pens that were bedded with gravel, sand, rice hulls, straw or wood shavings. The study took place from August to October. Each calf was assigned to one of the five bedding treatments. Indices used to describe calf health in this study were calf cleanliness, fecal score/scour days, and growth. Calves were dirtiest when housed on gravel and sand, because manure and wetness were not absorbed. Rice hulls were absorbent but had a tendency to stick to the calves' skin, leading to increased self-grooming and possibly bacterial transmission. Calves housed on gravel and sand had the most number of scour days, whereas calves on wheat straw and wood shavings had the least number of scour days and the most desirable fecal scores. This effect may be due to the fact that scours could be more readily recognizable on the less absorbent bedding surfaces.

Wheat straw was the most expensive bedding, followed by sand and gravel. Shavings and rice hulls were the least expensive; however, bedding price varies depending on region and availability. The authors also did not take into account the cost of bedding delivery. In some cases, hauling costs for sand and gravel can be higher than the cost of the bedding itself.

Bedding type in this study did not affect calf growth or performance, and these results confirm data from similar studies. Bedding type does not appear to affect performance of preweaned calves. The authors mentioned that this study was conducted during a period of mild temperatures and should be repeated during colder months when bedding that is unsuitable for "nesting" behavior may increase cold stress.

Another management factor linked to raising healthy calves is fly control. Calf bedding choice can drastically affect fly populations, not only in calf housing areas but on the entire farm. A single calf hutch can produce 25,000-40,000 adult stable flies per summer (Schmidtmann 1991). Stable flies from calf hutches not only attack calves but spread to the surrounding area where they bite adult cattle and can compromise sanitation in the milking parlor. Stable flies have a painful bite and can disrupt feeding and resting behavior in cattle. The exact habitat preferred by stable fly maggots is not known, but it appears that they prefer high organic matter, high moisture content and high bacteria levels. Calf hutches provide an ideal environment for stable

fly maggots especially when bedded with straw or another organic material. A 1991 study reported a 99 percent reduction in stable fly maggots when sand and gravel were used compared to straw. When sawdust was used, the reduction in maggots was 81 percent compared to straw. It is recommended that calf bedding material should be evaluated during summer months when fly populations are highest.

Bedding should always be chosen with calf health and cleanliness in mind. According to data from recent studies, bedding type does not affect weight gain from birth to weaning but does affect the number of scour days. More scour days increase costs for the farmer and may lead to growth and breeding issues later on. Calves stay cleanest on an absorbent bedding material, such as sawdust, shavings or straw. Rice hulls are absorbent but should be avoided because they encourage self-grooming and possible environmental bacteria transmission to the calf. Straw provides an ideal environment for stable fly maggots, while sand and gravel suppress maggot populations but can provide a dirty environment for calves. Sawdust is recommended as an absorbent bedding material, which significantly suppresses stable fly maggot populations. It is worth considering another type of bedding that allows "nesting" behavior in winter months when gravel, sand and sawdust may not be appropriate.

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For further reading or complete data, refer to the following:

Camiloti, T.V., Fregonesi, J.A., Von Keyserlingk, M.A.G., and Weary, D.M. (2012). Effects of bedding quality on the lying behavior of dairy calves. J. Dairy Sci. 95:3380-3383.

Panivivat, R., E.B. Kegley, J.A. Pennington, D.W. Kellogg, and S.L. Krumpelman. 2004. Growth performance and health of dairy calves bedded with different types of materials. J. Dairy Sci. 87:3736-3745.

Schmidtmann, E.T. 1991. Suppressing immature house and stable flies in outdoor calf hutches with sand, gravel, and sawdust bedding. J. Dairy Sci. 74:3956-3960.

Stull, L. 1997. Stress and dairy calves. http://www.vetmed.ucdavis.edu/vetext/INF-AN/INF-AN_stressDairyCalves.pdf. Accessed August 2, 2012.

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