**Interpretative summary**

Our Industry Today: Survey of winter housing and bedding practices on Vermont organic dairy farms. Andrews. At least 27% of Vermont dairy farms are certified organic. Cows on organic dairies must be allowed daily pasture access during the grazing season. During winter months, cattle may be housed indoors due to inclement weather. There is limited knowledge of the frequency and diversity of winter housing and bedding systems used for lactating dairy cows on organic dairy farms. In this project, we surveyed organic dairy farmers in Vermont to estimate the frequency and diversity of winter housing and bedding systems.

**Our Industry Today: Survey of winter housing and bedding practices on Vermont organic dairy farms**

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**ABSTRACT**

We conducted a survey to quantify the frequency and diversity of housing and bedding practices used by organic dairy farmers in Vermont, achieving a high response rate. This report describes the survey methods, results, successes, limitations, and lessons learned from administering the survey. Beginning in December 2018, a short questionnaire was administered by web, mail, and telephone to a source population defined as all producers of organic dairy cow milk in Vermont (*n* = 177) listed in the United States Department of Agriculture Organic Integrity database. Our approach yielded an 82% (*n* = 145) response rate from certified organic farms producing organic cow’s milk in Vermont at the time of the survey.

The three most common housing and bedding material combinations used by respondents were tiestall housing with wood bedding (45%), freestall housing with wood bedding (14%), and freestall housing with sand bedding (12%). The median number of lactating cows on farms among respondents was 59.5 (range 2 to 400), and the odds of using more than one type of facility to house lactating cows increased with the number of lactating cows reported for a herd. Four primary categories of cattle breeds were identified among the respondents’ herds: 1) Holstein cattle only; 2) Jersey cattle only; 3) mixed Holstein and Jersey herds with crosses; and, 4) mixed Jersey and Holstein herds with one or more additional breeds. Breed distribution was similar across the housing and bedding type categories. An association between frequency of individual cow milk somatic cell count testing and housing type was identified; respondents using freestall sand facilities tested less frequently than herds in tiestalls with wood bedding. The survey length limited information gathered, but overall provides valuable insight on Vermont organic dairy housing and bedding practices.

*Key words.* dairy cow, certified organic, questionnaire, tiestall, freestall, bedded pack, survey methods

**INTRODUCTION**

Dairy cattle housing and bedding systems influence animal health, reproduction, milk quality, animal well-being, productivity and farm profitability (Bewley et al. 2017). Future trends of dairy cattle housing will reflect consumer demands, animal behavior, and environmental impact (Bewley et al. 2017), and the long-term sustainability of the dairy industry depends on the extent that housing systems reflect these priorities (Beaver et al., 2020). In 2014, tiestall housing systems were the most common housing types for lactating cows among all operations in the US and foremost among operations with less than 100 cows (USDA 2016). However, it is unknown whether this trend also applies to lactating cattle on organic farms in the US. Regional differences in herd size and types of facilities exist among US dairy operations (USDA 2016), and it is unclear how Vermont organic dairy farms compare to the other northern tier US states that lead in organic dairy production, e.g., Wisconsin, New York, Pennsylvania, Maine, and Minnesota (O’Hara and Parsons, 2013; Richert et al., 2013).

Vermont ranks sixth by number of certified organic dairy farms per state and first by number of certified organic dairies per square mile in the US (USDA-NASS, 2017). In 2018, 27% (*n* = 197) of Vermont dairy farms were certified organic; a subsequent count in January 2019 reduced the number to 177. US organic production regulations stipulate living conditions provide “year-round access for all animals to the outdoors, shade, shelter, exercise areas, fresh air, clean water for drinking, and direct sunlight, suitable to the species, its stage of life, the climate, and the environment” and pasture access providing “a minimum of 30 percent of a ruminant's dry matter intake (DMI), on average, over the course of the grazing season(s)” (USDA, 2020). Temporary confinement or shelter is allowed because of inclement weather or conditions which could jeopardize the animals’ health, safety, or well-being. In the northern US, including Vermont, where inclement weather may dominate in winter months, organic dairy herds may be housed indoors for extended time periods. Reported frequencies of milking facility types (e.g., parlor vs. tiestall or stanchion milking) on organic dairy farms in other northern states (Minnesota, New York, Oregon and Wisconsin) may provide a crude estimate of corresponding housing facilities, but do not provide reliable estimates of winter housing or bedding management practices (Stiglbauer et al., 2013; Sorge et al., 2016). For example, pasture or dry-lot was designated as the primary housing type (110 of 192 farms) for lactating cows on organic farms in New York, Oregon and Wisconsin (Richert et al., 2013), but only 22% of farm visits were conducted in the winter. It is possible that seasonality of a survey could bias the primary housing type reported. Further, these surveys did not capture the type of bedding material used, and some styles of housing (e.g., loose- or open housing pack barns) appear to be less frequent in these studies.

Bedded packs, compost bedded packs, or loose-housing systems are designed for cow comfort, with an open floor plan in an enclosed structure and bedding that is refreshed regularly (Leso et al., 2020). Although it is unclear how many US organic dairy farms have adopted this technology, use of loosehousing (including compost bedded pack but excluding freestall) for lactating cattle increased between 2007 and 2014 from 3.4% to 6.4% of all dairy facilities and from 3.5% to 8.5% of dairies with herd size less than 100 cows (USDA 2010, 2016). In Vermont and nationally, the construction and use of bedded pack or compost bedded pack facilities is promoted as an alternative to traditional housing systems (Bewley et al., 2012; Gilker at el., 2012; Ogejo, 2018; Endres and Janni, 2019). Compost bedded packs are found to increase cow comfort, increase lying times, decrease lameness, and improve hygiene, factors that are relevant to farm productivity and may be important to consumer preferences and market access (Beaver et al., 2020, Leso et al., 2020). However, a paucity of information on the distribution and types of bedding management styles implemented on organic dairy farms nationally or regionally in the US makes it a challenge to properly design and conduct observational studies to identify associations between housing systems and productivity or health and welfare outcomes, such as mastitis and lameness.

The objective of this descriptive study was to gain a reliable estimate of the frequency of bedding management and housing in use on organic dairy farms in Vermont, specifically aiming to quantify producers using a bedded pack system. Due to a small target population, confidence in our results depended on a high response rate. To address this challenge, we designed and implemented a short format questionnaire that was administered by multiple methods with two follow-ups. This report discusses both methodology of administration and results of the Vermont Organic Dairy Winter Housing and Bedding Survey.

**MATERIALS AND METHODS**

The primary objective of our survey was to estimate the frequency of different housing and bedding types used on organic dairy farms in Vermont. The survey tool was a short questionnaire designed to be administered by multiple methods (mailed, internet-based, telephone interview). The process included initial outreach, survey distribution through online access and mailed paper copies, follow-up mailings and telephone reminders with the opportunity to complete the questionnaire by telephone interview. Survey methodology was approved by the Institutional Review Board at the University of Vermont (CHRBSS: 19-0057), and respondents received no reimbursement for completion of the survey. The Strengthening the Reporting of Observational Studies in Epidemiology statement checklist for Veterinary medicine (STROBE-Vet; O’Connor et al., 2016) was considered during survey design and reporting results.

***Sampling Method***

The target population was organic dairy farms in Vermont, US, with possible relevance to organic dairy farms in the northeastern United States. The source population was farms in Vermont, US identified from the publicly accessible USDA Organic Integrity (USDA-OI) database (<https://organic.ams.usda.gov/integrity/>) that were producing and shipping certified organic cow milk at the time of the survey. Dairy farm names and addresses were retrieved from the database using terms “Dairy cow: milk” and “VT-Vermont”. Two searches were performed. First, a search of the USDA-OI database, conducted 10 October 2018, yielded 197 farms. A second search of the same database on 10 January 2019 reflected an update in December 2018, and yielded a smaller pool of 177 farms. Results of the first search created the mailing list for the initial questionnaire, and results of the second search served as a reference for verification and is defined as the source population of certified organic dairy farms producing milk in Vermont.

***Questionnaire Design***

The survey tool was designed to be administered as a mailed questionnaire with the opportunity for participants to complete an internet-based version. We opted for a short-format questionnaire (8 questions) with the goal of achieving a high response rate, accepting the trade-off of accumulating limited specific data (Supplemental Figure S1; https://doi.org/10.3168/jds.20XX-XXXXX). Questions were crafted using the fewest words necessary, using terms assumed to be understood by dairy farmers, and limited in scope to avoid the need for a respondent to seek other sources of information such as farm records. Multiple question types were used, e.g., open “fill-in-the-blank” questions on number of lactating cows, years of farming experience and breed(s) of cattle, and closed multiple choice questions on winter housing type, bedding material use and milk somatic cell count testing frequency. A third option “other, fill-in-the-blank” was included for multiple choice questions on housing and bedding types as we anticipated a possible range of responses beyond the categorical choices we provided.

The survey tool began with a statement informing participants of confidentiality and introduced the goals of the study and the URL address of the web survey version (refer to S1). Personal identifiable information was limited to farm name and location. This information was included to identify and eliminate duplication of results across the three survey administration methods (e.g., if a farm completed both the mailed and internet-based versions). The assurance of confidentiality was reiterated at the end of the question section, just before a boxed section that asked for contact information for the farm. The questionnaire was pre-tested for clarity with members of the research team not involved in the initial question design and with the herd managers of the conventionally-managed University of Vermont dairy research herd.

***Questionnaire Administration***

The survey tool was distributed through direct individual mailings and as an online version shared through social media and other outreach. The web-based questionnaire content was identical to the paper version and was created using Lime survey software (<https://www.limesurvey.org/>). The web-based questionnaire format was tested by research team members prior to opening for public access.

The web-based questionnaire went live on 7 December 2018 and was available until 1 May 2019. During the week following live access to the web-based survey, the source population was informed of the study via announcements on University of Vermont Extension social media platforms and newsletters, and through a press release sent to local newspapers, agriculturally focused web-based news outlets, stakeholder email list serves, and organic association e-newsletters. Digitized announcements included a URL link to the web-based questionnaire.

The first mailing, including the questionnaire, study goals description and a separate stamped, self-addressed return envelope, was mailed on 21 December 2018 to the 197 farms in the USDA-OI database from the October 2018 search (Fig. 1). A telephone call reminder was made the week of 21 February 2019 to farms that had not yet responded to either the mailed or web-based forms. Respondents who answered the call were given the opportunity to complete the questionnaire as a telephone interview; otherwise, if possible, a reminder message was left with a telephone number to call if the farmer preferred a telephone interview. After cross-referencing the updated USDA-OI database, a second mailing was distributed on 6 March 2019 to farms that had not yet responded (87 farms of the 177 in the December 2018 updated USDA-OI database). To eliminate duplicate contact attempts, identifying information (farm name) from completed questionnaires was used to identify non-responding farms for each successive administration of the survey, but this private information was not included in any downstream analyses. The second mailing included a partial-sheet disclaimer to apologize if the recipient had already completed the survey in another format and to prevent multiple submissions from the same farm.

***Analyses of Survey Responses***

Individual farms were identified by a numerical code and questionnaire response data were separated from identifying information and digitally entered using Microsoft Excel*.* Data from the web-based questionnaire was exported as a CSV file and merged into a single file with the mailed and telephone response data. The format for survey completion was recorded for each respondent and occasional duplications removed (i.e., farms that responded by more than one method). Missing data for individual questions were identified and excluded from statistical analysis. To test association between SCC testing frequency and other variables, SCC testing responses were reduced to a binary outcome of SCC testing approximately monthly or greater (“yes” *n* = 90, or “no” *n* = 52). All statistics were performed using R 4.0.2 software.

Descriptive summary statistics were calculated for each question. Calculation of 95% confidence intervals (CI95) on observed proportions for types of housing and bedding systems used by respondents and reported frequency of SCC testing was performed using the DescTools package (Signorell et al., 2020). Independence of categorical variables was assessed with Pearson’s chi-square test. Kruskal-Wallis (K-W) rank sum test was used to test associations between ordinal dependent variables and independent variables with multiple categories, and when significant differences were observed the Dunn test for multiple comparisons with adjustment was applied using the FSA package (Ogle et al., 2020). Relationships between categorical independent variables with two or more levels and continuous dependent variables were assessed using one-way analysis of variance (ANOVA). Associations between binary dependent variables and independent predictors were tested by logistic regression; post-hoc pairwise associations were tested for significance using Tukey’s Honest Significant Difference Test. *P* values were assigned to assess significance (*P* ≤ 0.05) of association.

**RESULTS AND DISCUSSION**

***Survey Methodology***

The overall response rate was 82% (*n* = 145) of 177 certified organic dairy farms producing cow milk in Vermont. Three producers reported they were no longer active dairy producers via the first mailed survey and two reported selling their herd when responding by phone (excluded from analysis). Four additional farms responded that were located outside of Vermont (excluded from analysis).

The number of Vermont organic dairy operations is dynamic; for example, the number of organic dairies in Vermont increased from 184 in 2015 to 203 in 2016, and then declined to 187 by 2019 (Vermont Agency of Agriculture, 2020). USDA-OI data are provided by USDA-Accredited Certifying Agents (certifiers) and databases are updated by certifiers monthly or more frequently. At the time of our initial USDA-OI database search, it was unclear when the database had last been updated. We discovered that it is useful to confirm that the database being used to identify the source population is the most current to report an accurate response rate. For example, we identified that the USDA-OI December 2018 update listed 20 fewer farms (10% of the initial source population), which allowed us to adjust the size of subsequent mailings to match the updated database. We would have underestimated our response rate and/or received responses from farmers no longer in the source population (i.e., no longer actively shipping organic milk) if the update was not completed or the new data pool was not used.

The initial response to the web-based questionnaire was 26 producers, 15% of the source population (Figure 1). Web responses were received between days 4 and 45 of the 144-day live period of the survey. In contrast, the response to the first mailing was 75 participants or 42% of the source population within 75 days of the initial mailing. Telephone and mailed reminders accounted for 18 and 26 additional responses, respectively (Figure 1).

The rate of response far exceeds what is described as typical for mailed questionnaires administered to farmers (Pennings et al., 2002; Pereira et al., 2013). While mailed questionnaires are most commonly used, at least partly due to cost and convenience advantages, their low response rate can be a barrier to obtaining a representative sample (Pennings et al., 2002). Potential factors that influence response to mail surveys among farmers include the 1) timing of administration in context of seasonal farm production schedules, 2) length of the questionnaire and amount of time perceived to complete the mail survey, 3) potential compensation for participation, and 4) limiting questions to those that do not require farmers to consult records for factual information (Pennings et al., 2002). The subject’s interest in the topic of the questionnaire, content of the cover letter introducing the study, its “sponsors,” and the stated goals of the study (including intended use of the data) also influence response, as does the use of follow-up reminders (Pennings et al., 2002). We suspect the same factors may apply to farmers’ response to questionnaires administered by other methods, such as internet-based or telephone, although in our review of the literature we were unable to find published research exploring these factors. Response frequency and timing appeared to differ among the administration methods, suggesting organic dairy farmers may respond to different questionnaire administration methods more readily, although our study was not designed to test this hypothesis. Further research seems warranted to explore dairy farmer preferences for questionnaire formats and administration methods and the effect of using multiple methods on survey response frequencies.

Additional factors that may have contributed to a high response frequency for this survey include relatively short length of the questionnaire and advertisement and administration of the survey in the “slower” winter season. Timeliness of the topic and interest to members of the source population, also known as “selection by the respondent,” may have also been a factor (Pennings et al., 2002). Producer interest in the subject matter was measured by question 8 and appeared to be high with greater than 65% of respondents overall indicated they were “somewhat” or “very” interested in the survey results. Respondent interest was associated with the method of administration (K-W chi square = 14.35, *P =* 0.002) (Table 1). The proportion of respondents indicating “very” interested in the survey results was highest for those completing a web-based questionnaire, and pairwise comparisons indicated the distribution of responses among web-based respondents differed from those who responded to the first and second mailings (adjusted  *P* = 0.024 and 0.001, respectively). This suggests an interest in the study may have motivated web-based participation, although it is likely other factors influenced the choice between completing a survey on the internet or by mail. Neither years of dairy farm management experience nor total years of organic dairy farming experience were associated with method of survey response (*P* = 0.73 and 0.74, respectively).

Completion of 70% of web-based questionnaires occurred between 10-13 December 2019, when the first media communication went out, and 21-23 December 2019, when the first mailing was delivered. While this suggests the importance of multiple reminders from varied media, no additional web-based participation occurred after the telephone reminder or second mailing, further supporting our speculation that web-based participation was related to interest level, or to timing of initial social media advertisements, among other factors. In contrast, respondents to the second mailing had the lowest proportion of “very” interested and a high proportion with no interest in survey results. Respondents interviewed by telephone also had a high level of interest (56% “very”). It is possible that web-based respondents would have also responded readily to the mail survey or telephone call, had they not first filled out the web survey. While response rates for internet-based questionnaires may be lower than mail-based surveys, when evaluated in a survey of American households, internet tools did not appear to exhibit item non-response bias (Hudson et al., 2004). In the context of our survey, the addition of an internet-based approach did not significantly increase the cost of our survey and had some advantages in ease of data processing. We speculate that internet-based administration can be an effective supplemental option to mailed questionnaires. Additional research is needed to determine if internet-based questionnaires are a suitable mode of administration when used as the only option for farmer populations, especially given potential issues related internet coverage in rural areas and possible self-selection bias related to demographic variables such as age (Hudson et al., 2004).

We suspect that the timing for survey administration contributed to the high response rate. The survey was promoted and conducted in winter months when field work was at a lull. The farmers in the source population may have had more time available to participate.

The short survey length may also have contributed to the high response rate. Conversely, the length was also a limitation, constraining the information collected by the survey, including why respondents demonstrated interest in this topic area. In retrospect, we believe this issue is particularly interesting given that housing and bedding management was not identified as a research and education need in a previous survey of organic farmers in the northeastern US (Pereira et al., 2013). Additional research would be necessary to understand the true motivation behind the high response rate. For example, did the respondents’ perceived challenges with current housing and bedding systems motivate their reported interest and likelihood of responding, or is this farmer population considering alternative housing and bedding systems? As one farmer commented on the web-based survey, “I am very interested in the relationship between housing type, bedding type and pathogens . . . I hope there will be [a] more in depth survey at a later date.”

***Survey Results***

***Housing and Bedding Styles and Materials***. All survey respondents provided information on the type of facility used, while one respondent did not report the type of bedding used. Multiple housing systems were used on 15% of farms, while the remaining 85% reported using a single housing system. The most common housing type for lactating cows on farms that used a single housing system was tiestall (46%, CI95 39-55%) followed by freestall (29%, CI95 21-38%). Loose housing with no stalls or cubicles (including bedded pack) was used solely or in combination with another housing type on 17% (*n* = 25, CI95 12-24%) of farms. Among the 22 farms that reported using a bedded pack for lactating cows, 13 used this strategy in conjunction with another lactating cow housing type (“Bedded Pack Plus” Figure 2), including tiestall or freestall housing. Nine farms reported housing lactating cattle in both tiestall and freestall barns. Four additional farms reported using freestalls with both wood and sand bedding. There was a positive association between using more than one type of facility to house lactating cows and the number of lactating cows in respondent herds (*P* = 0.034). Future research might explore the reasons why some organic dairy farms are housing lactating cattle in different types of facilities. One possibility is simultaneous use of multiple housing types for larger herds is a result of herd expansion over time.

Wood-based bedding was the only material used on 70% (CI95 66-78%) of farms. Sand was the sole bedding material used on 12% (CI95 6-12%) of the farms and was limited to farms with freestall facilities (Figure 2).

Three major combinations of housing type and bedding materials were identified, each with 18 or more respondents: 1) sole use of a tiestall bedded with wood products (63 farms, 43%, CI95 36-53%), 2) sole use of a freestall bedded with wood products (21 farms, 14%, CI95 10-21%), and 3) sole use of a freestall bedded with sand (18 farms, 12%, CI95 8-19%). Additionally, a bedded pack system was reported on 22 farms (15% CI95 10-22%). However, of those using a bedded pack, thirteen farms (9%) reported use in combination with another type of housing system (e.g., tiestall or freestall) and nine (6%) farms reported using only a bedded pack housing system. Half of farms using bedded pack used only wood-based bedding and half used a combination of wood, hay, or straw. The remaining farms (14%) reported a mixed tiestall and freestall system (*n* = 9), tiestalls using non-wood-based bedding material (*n* =5), freestalls using both sand and wood (*n* = 4), or a loose housing system that was not described as a bedded pack and was bedded with wood products (*n* = 3).

Herds using bedded packs had the most variation in bedding and housing management practices. “Mixed” housing systems using bedded packs in combination with another style were common. As discussed above, to encourage a high response rate, questions were designed to be brief and targeted, which restricted the information provided in responses. For example, because it is always constructed in an open floor plan barn, we chose to include “bedded pack” as a housing style, rather than ask about loose housing and then clarify if it was managed as a bedded pack. Furthermore, while respondents were able to select more than one bedding or housing type, there was an open component to this question where respondents could write a short response specifying which bedding was associated with which housing type. While this had the effect of shortening the survey, it may have introduced some confusion among respondents who had multiple housing and or bedding types, or loose housing systems, introducing potential measurement error. No respondent who selected multiple housing and bedding strategies was specific about which bedding was used in each housing type, highlighting a limitation of the current survey method and format. Future surveys could incorporate alternative methods (e.g., interview questionnaires) or questionnaire designs that allow respondents to provide more detailed information. Given the high response rate of the current survey, we trust the estimates of the three most common housing and bedding types used on organic dairy farms in Vermont (tiestalls with wood products, freestalls with wood products or freestalls with sand), and have identified some challenges with characterizing housing and bedding management practices on farms that did not fit these categories, which were approximately 30% of respondents, and included farms using solely bedded pack housing systems.

Survey administration type was associated with housing/bedding system (chi-square = 21.68, *P* = 0.04; Figure 3). Producers using bedded pack and freestall wood systems were the most common users of the web-based survey (32% and 43% of each) relative to all other housing bedding types (average 12% among all categories). Correspondingly, producers using bedded pack or freestall wood systems responded with high level of interest (91% and 88% “very” or “sorta” interested, respectively). In contrast, producers using a freestall bedded with sand exhibited the greatest “nope” not interested and least “very” interested and this group did not show a preference for survey administration types. We speculate providing multiple modes of questionnaire administration contributed to the high response rate across the range of interest levels and management styles.

Although the frequency of organic dairy farmers using bedded packs is low relative to other types of facilities, we speculate that an interest level in this system may have motivated producers to participate in the survey, and that respondents may have been influenced by our university’s reputation, prior research and publications related to bedded pack housing systems or mastitis control of organic dairy farms (Pennings et al., 2002). Additionally, the press release (Supplemental Figure S2; https://doi.org/10.3168/jds.20XX-XXXXX) highlighted our research interests in bedded pack specifically and this may have evoked reciprocation influence (Groves, 1990).

***Cattle Breeds***. We grouped breed types reported by respondents into four categories: 1) Holstein only 2) Jersey only 3) mixed Holstein and Jersey herds with crosses, or 4) mixed Jersey and Holstein herds with one or more additional breeds. Three respondents did not report the breed(s) of cattle on their farm and were excluded from analysis of breed associations with facility and bedding types. While breed distribution was similar across the housing and bedding type combination categories (*P* = 0.1), five of nine (55%) producers using only bedded pack style housing reported using Jerseys and Jersey crosses compared to the next highest proportion of Jersey herds among tiestall farms (*n* = 19, 30%) and freestall farms (*n* = 8, 22%) (Table 2).

***Frequency of Individual Cow Somatic Cell Count Testing***. Data on the frequency of individual cow milk somatic cell count (SCC) testing was collected because our research group is interested in conducting future studies on the relationship between bedding practices and mastitis in organic dairy herds. Three respondents did not report SCC testing frequency on their farm and were excluded from analysis of associations between SCC testing and facility or bedding types. Ninety (63%, CI95 56 – 71%) of 142 producers reported testing SCC for individual cows approximately monthly or more frequently (Figure 4). In previous surveys, 69% of 35 organic dairy farms in Minnesota (Sorge et al., 2017) and 53% of 192 organic dairy farms in New York, Oregon and Wisconsin (Stiglbauer et al., 2013), reporting using DHIA services, although neither study appeared to explore how organic dairy farmers use DHIA testing data, frequency of SCC testing, or if SCC testing frequency was associated with other management practices. There was a direct association between housing type and SCC testing frequency (*P* = 0.019). Producers using freestall sand facilities were less likely to test approximately monthly or greater compared to those using tiestalls with wood bedding (*P* = 0.012). Number of lactating cows was not associated with SCC testing frequency (*P* = 0.17) and inclusion of both housing type and herd size did not improve the overall fit of the model compared to the model with only housing type.

While our estimate of individual cow SCC testing frequency appears to be similar to the frequency of DHIA testing reported previously (Sorge et al., 2017; Stiglbauer et al., 2013), the accuracy of our results may have been restricted and possibly underestimated due to the wording of our survey question. As an example of individual cow testing, we provided an acronym, DHIA (Dairy Herd Improvement Association), commonly associated with a regular testing service that can include individual cows SCC testing. This may have suggested that we were asking about subscription to a regular testing service. For example, one producer reported never performing individual cow SCC tests but then noted in a comment that the California Mastitis Test was used for testing individual cows on their farm. Routine California Mastitis Test (CMT) or cow-side SCC testing has been reported to be used more frequently than DHIA testing on organic dairy herds, so it is likely organic dairy farms in our source population also use alternative mastitis screening tools like CMT (Stiglbauer et al., 2013) Further research is needed to quantify mastitis control practices in this target population.

***Number of lactating cows****.* One respondent did not report the number of lactating cattle on their farm and was excluded from analysis of herd size associations with facility and bedding types.The median lactating cow herd size among the remaining 144 respondents was 59.5 cows (range 2-400, mean 71, standard deviation 4.5, CI95 62 – 80 cows; Figure 5). The number of lactating cows reported by respondents is in the range reported by other surveys of US organic dairy farms (Sorge, 2016). The number of cows varied between housing bedding types in this study population (*P* < 0.001) while past surveys of US organic dairy farms did not appear to explore this association (Sorge et al., 2017; Stiglbauer et al., 2013). Producers reporting using freestall systems bedded with both sand and wood typically housed more cows than any other housing system aside from producers using a bedded pack combined with another housing system (*P* ≤ 0.05 in post hoc pairwise comparisons), and the largest herds were associated with freestall facilities either used alone or in combination with other facility types. Despite these differences, most producers using freestall barns had a similar herd size to all other housing strategies (Figure 5).

Twenty-two herds (15%) reported using a combination of facility types, including 9 herds using freestalls and tiestalls and 13 herds using bedded-pack and an additional housing system. As discussed previously, the use of multiple or combination facility types was associated with an increased number of lactating cows.

The short format questionnaire limited our ability to collect more detailed information about herd size history, facility age, and multiple housing and bedding strategies. For example, we can speculate if a producer had two free stall barns, one of which was bedded with sand and the other with sawdust, they would have reported housing style as “freestall” and bedding as “sand” and “wood”, without reporting multiple barns. Likewise, farms that used a bedded pack barn in combination with another housing type might have more overall cow space available than a farm with a single barn type. This may explain elevated cow numbers in these categories. Other studies have investigated herd size and facility age, but not together within the same survey. For example, Sorge et al. (2016) reported a 10 year mean change in herd size of 5.7 cows (range -11 to +30), but did not report on changes in facility types, while Stiglbauer et al. (2013) reported the mean age of housing (36.5 years) but did not report changes in herd size or facility types for US organic farms. Future surveys might collect more specific data on farms that use multiple housing and bedding types as well as whether farmers are planning for responding to future pressures on the industry to develop “cow-friendly” housing systems.

***Years of Dairy Farming Experience****.* Years of experience could be perceived as a variable in studies measuring the impact of management. Nineteen respondents did not report years of dairy farm management experience, however, all but one of these respondents reported years of organic dairy farm management experience. Respondents’ overall years of dairy experience varied among all housing/bedding categories *(P =* 0.2) (Figure 6). The years of organic dairy farm experience had a narrower range than length of the total dairy experience, we suspect because many producers transitioned to organic from conventional dairy management. While organic experience mostly did not differ between housing/bedding strategy, producers using a tiestall without a wood-based bedding (“Tiestall other bedding”) worked more years in organic dairy production than producers managing herds in freestall sand facilities (*P* = 0.04). This difference was not found for overall experience (Figure 6), perhaps suggesting that producers in this source population using freestall sand facilities were the most recent to transition to organic dairy production.



***Future Housing Trends and Research Priorities for Organic Dairy Farms****.* In the United States, producers of organic ruminant livestock must provide daily grazing to their herds throughout the grazing season and year-round access to the outdoors. US organic dairy farmers may provide temporary confinement or shelter for animals because of inclement weather, and animal health, safety and well-being, among other reasons. Shelter or housing for US organic dairy cattle must be designed to allow for: “(i) Natural maintenance, comfort behaviors, and opportunity to exercise; (ii) Temperature level, ventilation, and air circulation suitable to the species; and (iii) Reduction of potential for livestock injury” (USDA, 2020). To the best of our knowledge, research on shelter or housing for US organic dairy farms is limited. We propose that research on the impact of housing and bedding on organic dairy cattle productivity and well-being, including animal health (e.g., lameness and mastitis) would inform best practices regionally and nationally, especially for regions where winter housing and bedding technologies are used for five to six months of the year. Our survey improves knowledge of lactating cow housing and bedding types used on organic dairy farms in our region and in the process also identified some key issues for further study. In particular, given the relatively high frequency of tiestall housing facilities in this sample, research is sorely needed on how organic dairy producers perceive and are responding to changing consumer demands related to confinement housing.

Better knowledge of the distribution and types of bedding management styles practiced on organic dairy farms is necessary to identify representative samples for research populations. Research on the relationship between housing types and animal behavior, health, and well-being and environmental impacts is important to help direct the future of housing for dairy cattle and could help inform consumer acceptance of common cattle husbandry systems. For example, a picture-based approach used to assess the public acceptance of common indoor housing systems in Germany found that the acceptance of loose housing (freestall barns) was relatively low (17% or less) and paddock or pasture access increased public acceptance (Kühl et al., 2019). Notably, their study did not include an assessment of consumer acceptance of either confinement tiestall barns with pasture access during good weather (the most common scenario among respondents in our sample population of organic dairy farms) or loose housing bedded pack systems with pasture access during good weather (Leso et al., 2020).

Bedded pack, compost bedded pack, or loose housing systems, where cows have an enclosed structure with an open floor plan and bedding that is refreshed regularly, are designed for cow comfort (Astiz et al., 2014; Leso et al., 2020). Fewer foot and leg injuries are cited in loose-housing bedded pack or compost bedded pack systems compared to freestall barns (Burgstaller et al., 2016). There are also reports of decreased incidence of mastitis for dairy cows housed on compost bedded pack (Astiz et al., 2014). Bedded pack compost material is a highly suitable soil amendment which can increase soil organic matter and fertility (Leso et al., 2020). Despite these potential benefits, our survey results indicate the adoption of compost bedded pack technologies for lactating cows on organic dairy farms in Vermont is relatively limited. We suggest that understanding the potential benefits of and barriers to transitioning organic dairy farms from tiestall confinement facilities to alternative housing is a critical research need for the organic dairy industry in our region, and perhaps globally.

**CONCLUSIONS**

Our survey found that tiestall barns bedded with wood products are the dominant winter housing system for lactating organic dairy cattle in Vermont. We identified a diversity of housing systems including a number of farms using mixed housing and bedding styles in organic dairy production in Vermont. We conclude that developing a simple survey on a useful topic and timing the survey for the potential availability of the target population can result in a high response. Future research in this area should leverage this interest to foster key relationships with organic producers to build a more robust research and extension program supporting housing and facilities management. The methodology presented here may be applied in other regions to survey farmers in organic dairy production.

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Vermont Agency of Agriculture. 2020. At this stage this is a personal communication from Diane Bothfeld via her monthly dairy reports – need to find where this is available on the web site of back into the USDA NASS data

Tables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 1. Frequency (%, within column) of participant interest level in the project results, stratified by the questionnaire administration method used by respondents | | | | | |
| Self-reported interest level |  | | | | |
| Mail 1 | Mail 2 | Phone | Web | Total |
| Did not Respond | 7 (9.3) | 1 (3.9) | 0 (0) | 3 (11.5) | 11 (7.6) |
| Nope | 9 (12.0) | 6 (23.1) | 4 (22.2) | 0 (0) | 19 (13.1) |
| Not Really | 11 (14.7) | 3 (11.5) | 1 (5.6) | 2 (7.7) | 17 (11.7) |
| Sorta | 24 (32.0) | 13 (50.0) | 3 (16.6) | 6 (23.1) | 46 (31.7) |
| Very | 24 (32.0) | 3 (11.5) | 10 (55.6) | 15 (57.7) | 52 (35.9) |
| Total | 75 | 26 | 18 | 26 | 145 |

Table 2. Reported frequency (%, within column) of breed in use by respondent dairy farms among housing and bedding styles. Three farms, one from each of bedding styles Freestall Sand, Freestall Wood, and Tiestall Wood did not indicate breed and are not included here (*n* = 143). onespecified in the table; breeds used on a single farms were included as “other”.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Housing Bedding Style | | | | | | | | | | |
|  | Bedded Pack | Bedded Pack Plus | Freestall & Tiestall | Freestall Sand | Freestall Sand & Wood | Freestall Wood | Loose Housing Wood | Tiestall Other Bedding | Tiestall Wood | Total |
| Ayrhire, Holstein, Jersey, cross | 1 (11.1) | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 0 (0) | 0 (0) | 1 (16.7) | 2 (3.2) | 5 (3.5) | |
| Ayrshire, Jersey | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 3 (4.8) | 3 (2.1) | |
| Holstein | 0 (0) | 4 (30.8) | 3 (33.3) | 2 (11.8) | 3 (75) | 8 (40) | 0 (0) | 0 (0) | 16 (25.8) | 36 (25.2) | |
| Holstein cross | 0 (0) | 1 (7.7) | 0 (0) | 1 (5.9) | 0 (0) | 1 (5) | 0 (0) | 0 (0) | 0 (0) | 3 (2.1) | |
| Holstein, Jersey | 1 (11.1) | 1 (7.7) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 2 (3.2) | 4 (2.8) | |
| Holstein, Jersey, cross | 1 (11.1) | 4 (30.8) | 2 (22.2) | 7 (41.2) | 1 (25) | 3 (15) | 0 (0) | 1 (16.7) | 13 (21) | 32 (22.4) | |
| Jersey | 4 (44.4) | 0 (0) | 0 (0) | 3 (17.6) | 0 (0) | 3 (15) | 0 (0) | 2 (33.3) | 17 (27.4) | 29 (20.3) | |
| Jersey cross | 1 (11.1) | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 1 (5) | 0 (0) | 0 (0) | 2 (3.2) | 5 (3.5) | |
| Mixed | 0 (0) | 1 (7.7) | 2 (22.2) | 1 (5.9) | 0 (0) | 0 (0) | 0 (0) | 1 (16.7) | 5 (8.1) | 10 (7) | |
| Other | 1 (11.1) | 2 (15.4) | 2 (22.2) | 1 (5.9) | 0 (0) | 4 (20) | 3 (100) | 1 (16.7) | 2 (3.2) | 16 (11.2) | |
| Total | 9 | 13 | 9 | 17 | 4 | 20 | 3 | 6 | 62 | 143 | |

Figure captions

Figure 1. Timeline of survey administration. Number of respondents over time using questionnaires administered on either web, first mailing, second mailing, or telephone call.

Figure 2. Number of farms within each housing strategy stratified by type of bedding material used. Each stacked bar represents a different housing strategy and pattern within bar represents the frequency of bedding material used within each strategy. Producers that reported using a bedded pack barn in combination with another housing type are grouped together (“Bedded Pack Plus”).

Figure 3. Proportion of farms using each housing/bedding type that responded to questionnaires by the method of administration. Bedded pack category includes all farms that reported using a bedded pack solely or in combination with another type of facility. Number (*n)* of respondents is shown adjacent to each survey type and category in the legend. “Other” category includes tiestalls not bedded with wood (*n* = 5), farms with both a freestall and a tiestall (*n* = 9), farms that used non-bedded pack loose housing (*n* = 3), and farms with freestalls with both sand and wood bedding (*n* =4).

Figure 4. Somatic cell counts (SCC) of individual cows in each housing/bedding strategy. Each stacked bar represents a different combination of housing strategy and bedding material. Pattern within bar represents frequency of SCC determinations on individual cows (*n* = 145).

Figure 5. Number of cows varies among housing/bedding types. Illustrated is a box plot with the center line as median (*n* =145). Points represent individual farm herd size.

Figure 6. Distribution of management experience in each housing/bedding strategy. Illustrated is a box plot with a median center line for years of a) organic dairy experience, and b) total dairy experience (*n* = 145).

Figures

Graphical user interface, text

Description automatically generatedAndrews 1

Andrews 2

Diagram

Description automatically generated

Andrews 3

Diagram

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Andrews 4

Diagram, engineering drawing

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Andrews 5

Diagram

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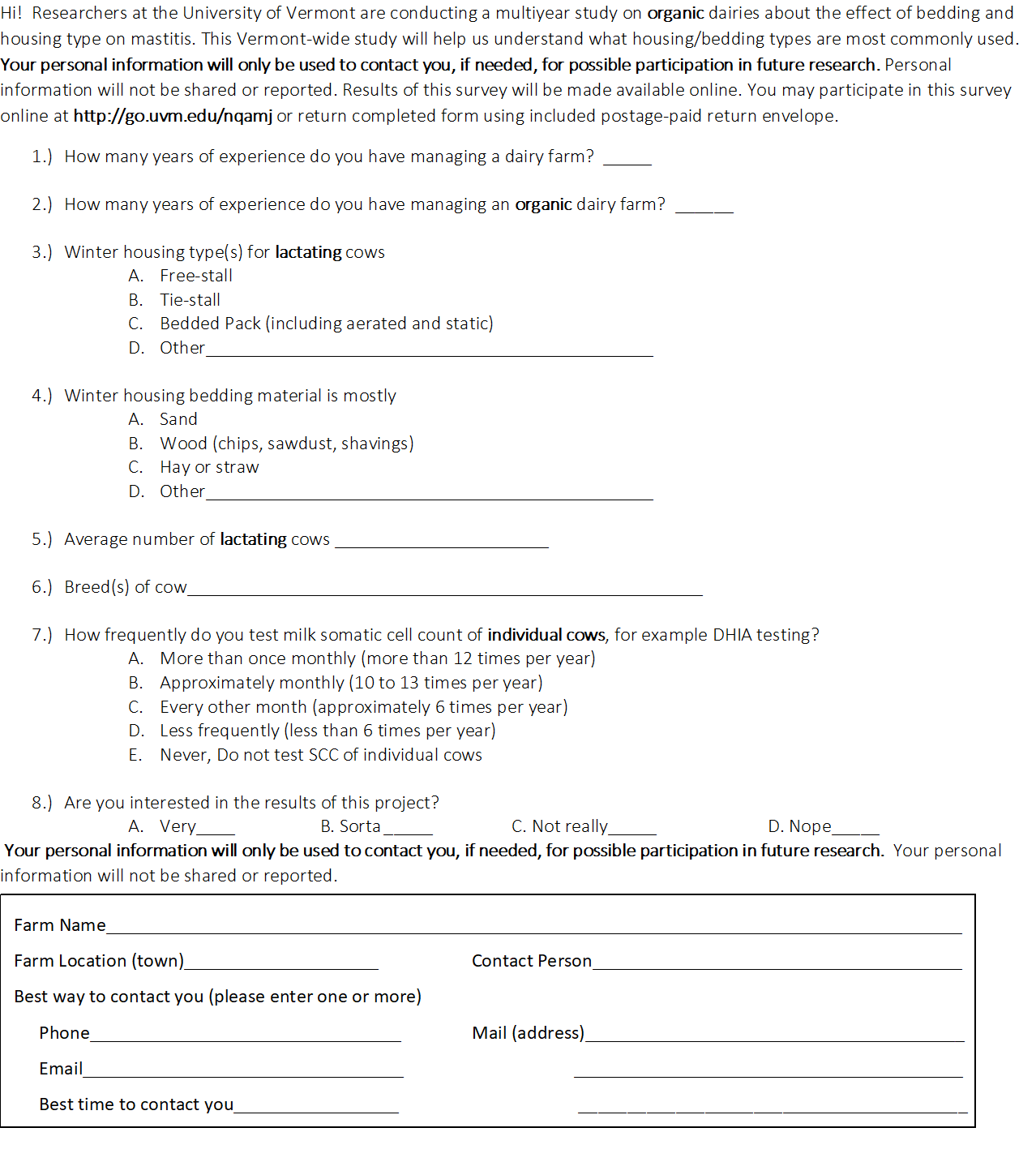
Andrews 6

Diagram, engineering drawing

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Supplemental materials

S1. Questionnaire



S2. Press Release