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Nutrition, reproduction, and young stock performance on dairy farms throughout Illinois: A Dairy Focus Team approach

M. I. Rivelli, S. Y. Morrison, PAS, K. J. Haerr, PAS, S. Rodriguez Zas, and F. C. Cardoso[1]
Department of Animal Sciences, University of Illinois, Urbana 61801

ABSTRACT

The world dairy industry has been changing over the last decades, and Illinois dairy farms are not an exception to these transformations. The objective of this study was to develop research and educational data that could help farmers to identify improvements and opportunities. To evaluate potential nutritional, reproductive, and young stock management opportunities, a total of 20 farms in Illinois were visited from May through June 2014.The farms were divided between the northern (NOR) and southern (SOU) regions of Illinois. During the visit to each farm, a questionnaire, DHI records along with the individual farm data set, samples of corn silage and TMR, and weather (ambient temperature, relative humidity, and wind speed) measurements were collected by a trained team of university and industry scientists. Average herd size was 413 ± 192 and 451 ± 949 lactating and dry cows for NOR and SOU, respectively. Average daily milk yield per cow was 37.9 ± 6.7 kg and 33.8 ± 5.7 kg for NOR and SOU, respectively ($P = 0.21$). Mean density of corn silage was greater for SOU than NOR (221.2 ± 8.2 vs. 168.5 ± 12.2 kg/m^3, $P = 0.003$). Dry matter content of the TMR offered to both lactating and dry cows was greater for NOR than SOU (48.7 ± 1.7 vs. 44.1 ± 1.0%, $P = 0.006$). Yearly pregnancy rate (19.8 ± 2.2 vs. 12.6 ± 1.6; $P = 0.006$) was greater for cows and heifers in NOR than SOU. Results suggested that geographical aspects such as weather differences (NOR vs. SOU) are important factors related to performance of dairy farms. Educational and extension programs tailored to the aforementioned differences might be more effective.

Key words: management, nutrition, reproduction, young stock

INTRODUCTION

The USDA (2007) reported that the number of farms with <50 cows has been decreasing and the number of farms with >100 cows has been increasing since 1991. Illinois dairy farms have experienced similar changes that have led to a 57% decrease in the number of total dairy farms and to a 40% increase in the average herd size during a 30-yr period (USDA, 2007). The emergence of new technologies and consumer concerns about food quality are changing the dairy industry. Farms are more productive because of their investment in new technologies and their implementation of targeted management programs (Brotzman et al., 2015). However, implementation of new technological and management practices is not always economically feasible (von Keyserlingk et al., 2013).

Knowing potential causes of inefficiency and efficiency of a farm is pivotal in improving its performance (Solís et al., 2009). To improve profits, dairy farmers need to optimize their operation's reproduction, management, and milk production simultaneously (Galligan, 2006). Productivity levels are linked to improvements in technology and efficiency, not to farm size (Cabrera et al., 2010).

Illinois data are in agreement with those described by the USDA (2007); therefore, it is necessary to develop new strategies that allow both small and large operations to improve farm efficiency. Dairy producers need to better understand how their own farms are performing and what the potential causes of inefficiency are. Overall, researchers' or government agencies' perspectives and goals are not necessarily the same as those of farmers; it is because of this that information should be focused on meeting the concerns or necessities of individual producers (Villamil et al., 2008).

Therefore, the objectives of this study were (1) to characterize the nutritional, reproductive, and young stock management practices of Illinois dairy farms and (2) to study potential geographical differences between the northern and southern regions in Illinois. Both objectives could provide important insight that may help dairy farmers and their advisors improve performance of their operations.

MATERIALS AND METHODS

Dairy Focus Team Approach

The Dairy Focus Team was established in 2014 as part of an extension program that encourages graduate and undergraduate students to further their knowledge by getting hands-on experience evaluating dairy farms as well as working with dairy producers to maximize profitability. The Dairy Focus Team was set up with a hierarchal structure of organization. The CEO is the faculty member and

[1] Corresponding author: cardoso2@illinois.edu

primary advisor of the team. Under the CEO, the president is a senior graduate student responsible for overseeing the training and management of the other chairpersons for each of the 5 individual sections to be evaluated on farm. The chairpersons were graduate students who were selected for the position based on their area of interest and experience. Each chairperson was responsible for the following sections for which they were assigned: nutrition, management, milk quality, reproduction, and young stock. Under each chairperson there were other graduate and undergraduate students who were interested in the section they were involved in and whose purpose was to learn and support the chairperson for each section during farm visits and during the postvisit evaluation of each farm. Additionally, the team had 2 groups of dairy mentors: one group of faculty and one group of industry members who were identified as additional knowledge and support to achieve the Dairy Focus Team objectives.

To standardize data collection a questionnaire was developed. Also, forms for each section were developed to ease data collection and to record specific information from each section (e.g., number of stalls in each pen, and number of cows drinking in each pen). All students were trained on how to use these forms, how to collect samples, and how to record measurements (e.g., wind speed, relative humidity, and temperature) by the respective chairperson of the section for which the form information would be used. During each farm visit the CEO, president, and chairpersons of each section all visited the farm. If a chairperson was unable to make the visit, then a trained member of the section went to the farm to collect the necessary data. After the initial visit and analysis the team got together and made the recommendations. The CEO and the president built up a report that contained all the farm analysis and recommendations. This report was mailed to each farmer with a personal code that allowed them to compare their data with those of the other farms visited during regional meetings where all results were presented (e.g., the regional Illinois Dairy Summit meetings held in northern, central, and southern Illinois sponsored by Illinois Milk Producers Association and University of Illinois Extension).

Research Approval

The University of Illinois Institutional Review Board (IRB # 14636) approved all procedures that were performed in this research. Prior to answering the questionnaire and sampling, all participants read and signed a consent letter that ensured confidentiality.

Farm Selection

For this study, a total of 20 dairy farms were selected based on their previous approval and willingness to participate in the study. Farms located north of Interstate 80 (latitude: 41°31′N) were classified as northern (**NOR**) and those located south of Interstate 80 as southern (**SOU**) farms. Fourteen of the farms were located in SOU (Piatt, McLean, Livingston, Tazewell, Brown, Marion, Shelby, Bond, Perry, St. Clair, and Vermilion counties), and 6 were located in NOR (Jo Davies, Stephenson, Carroll, Dekalb, and Rock Island counties). Minimum distance was 110 km and maximum distance was 492 km between northern and southern farms. Minimum and maximum distance between 2 farms was 9 and 492 km, respectively.

Questionnaire and Data Collection

A single visit from the team was conducted on each of the 20 farms selected. During each visit a questionnaire was administered by the CEO to the producer (owner) of each farm in a one-on-one interview. The questions were administered by a single person so that answers were in a similar format and were asked in a similar manner for all farms. The questionnaire had 6 sections: goals, management, dairy herd characteristics, nutrition, reproduction, and young stock. Nutrition, reproduction, and young stock sections were analyzed in this study (Table 1).

Simultaneously, the members of the Dairy Focus Team who were present for the farm evaluation collected corn silage (**CS**), TMR, and manure; and ambient temperature (**TEM**), relative humidity (**RH**), and wind speed measurements were collected. Also, DHI records along with an individual farm data set extracted from PCDART (Dairy Records Management Services, Raleigh, NC), Dairy Comp 305 (Valley Ag Software, Tulare, CA), Dairy Plan C21 (GEA Farm Technologies Australia Pty. Ltd., Tullamarine, Victoria, Australia), or AgriTech Analytics (Visalia, CA) herd management software were collected. Data were exported to Excel (Microsoft Corp., Redmond, WA) to build a final data set. Means and associated SD for milk yield and composition from the last test day (e.g., closest to the visit) and yearly values are shown in Table 2.

Nutrition

Trained personnel from the team collected CS, TMR, and manure samples. Samples of CS and TMR were taken on each farm and were sieved with the Penn State Particle Separator to determine particle size distribution (Kononoff et al., 2003). Corn silage and TMR samples were brought to the laboratory and dried at 55°C in a forced-air oven for 3 d (AOAC International, 1995) and then ground to pass through a 1-mm screen (Thomas Scientific, Swedesboro, NJ). Samples of TMR and CS were analyzed for contents of DM, CP, ADF, NDF, starch, sugar, Ca, P, Mg, and K using wet chemistry methods (Schalla et al., 2012) at a commercial laboratory (Rock River Lab, 2014).

Corn silage density (**CSD**) was measured on those farms that had either corn silage piles or bags (n = 4 in NOR; n = 11 in SOU). Density measurements were performed with a forage probe (Dairy One, Ithaca, NY) attached to a drill. Density samples were obtained from 5 different areas of each pile or silo bag (upper left, upper right, center, lower left, and lower right). Samples were weighed

Table 1. Questionnaire's description given to producers (owners) of 20 farms on northern (n = 6) and southern farms (n = 14) in Illinois

	Answer	
Question	**Yes**	**No**
Nutrition		
Does your farm measure dry matter intake for cows?	Yes	No
How many rations does your farm currently use?	≤2 Rations	>2 Rations
Do you push up feed?	Yes	No
How long does it take to feed?	≤2 h	>2 h
Do you weigh back refusals?	Yes	No
What is your farm target refusal?	≤2%	>2%
Do you shake out TMR in the Penn State box?	Yes	No
Do you know how many varieties of corn were used?	≤2	>2
Was the corn kernel processed?	Yes	No
Reproduction		
Do you know what percentage of dystocia your farm has?	Yes	No
Do you know what percentage of abortion your farm has?	Yes	No
Do you know what percentage of dead on arrival your farm has?	Yes	No
What is the farm's average days open?	≤150	>150
Do you know your farm's actual calving interval?	Yes	No
Does your farm breeding program use any type of hormone at some point?	Yes	No
What is your farm voluntary waiting period?	≤60 d	>60 d
Are bulls used for clean up?	Yes	No
Do you know if your farm has metabolic disorders?	Yes	No
Do you record calving scores?	Yes	No
Young stock		
When is the largest percentage of calf deaths?	Before the first wk of age	After the first wk of age
How much colostrum does each calf get in total?	≤3.78 L	>3.78 L
How much milk is fed per day?	≤3.78 L	>3.78 L
How many times is milk fed?	Twice/d	>Twice/d
At what temperature is milk mixed?	From 37 to 40°C	From 41 to 44°C
How long does it take to get the milk to the calf?	≤15 min	>15 min
Do you adjust amount fed depending on time of the year?	Yes	No
When is starter first offered?	Before 1 wk	>1 wk
Is starter intake estimated?	Yes	No
How often is water changed?	<2/d	≥2/d
At what age are calves weaned?	Equal or before 6 wk	After 6 wk
Do you have a vaccination protocol?	Yes	No

and dried to obtain DM and then density was calculated as recommended by the manufacturer (Dairy One, 2014).

Manure samples were collected for at least 5 lactating (**LACT**) and 5 dry (**DRY**) cows in the different pens of each farm and then composited by pen for measurement of apparent total-tract starch digestibility (Lopes et al., 2009; Schalla et al., 2012) at a commercial laboratory (Rock River Lab, Watertown, WI). For each sample, several small subsamples from fresh manure were collected with a spoon and place in a leak proof plastic jar with a wide mouth.

Reproduction

Yearly pregnancy rate (**PR**), first service conception rate (**FSC**), and services per conception (**SC**) were obtained from the individual PCDART data set from 11 farms (NOR = 4 and SOU = 7) and subsequently exported to Excel (Microsoft Corp., Redmond, WA). Pregnancy rate was calculated as follows: PR = [heat detection rate (% of heat detected) × conception rate (% breeding successful)]/100. Yearly PR was calculated as the average of all PR values from the previous year to the day of the visit. First service conception rate was calculated as follows: FSC = percentage of cows that conceived at the time of their first breeding. Yearly FSC was calculated as the average of all FSC values from the previous year to the day of the visit. Services per conception were calculated as follows: SC = number of services required to confirm that a cow is pregnant. Yearly SC was calculated as the average of all SC values from the previous year to the day of the visit.

Young Stock

Trained personnel on the team collected data for TEM, RH, and wind speed in at least 2 different randomly selected points either in calf hutches or calf barns on all farms. A final data set was built in an Excel file with the average of calf-hutch measurements and the average of calf-barn measurements. The TEM, RH, and wind speed were recorded using a hygro-thermo-anemometer-light meter (Extech 45170, Extech Instruments, Nashua, NH). Temperature humidity index (**THI**) was calculated as follows: THI = 0.8 × air temperature + [relative humidity × (air temperature − 14.4)] + 46.4 (McDowell et al., 1979).

Statistical Analyses

Statistical analysis was performed using SAS (v9.4, SAS Institute Inc., Cary, NC). Mixed models were created (MIXED procedure) to analyze CS and TMR components (DM, CP, ADF, NDF, starch, sugar, Ca, P, Mg, K, S, Penn State Particle Separator), CSD, TMR apparent total-tract digestibility (DM and starch), PR, FSC, SC, and young stock housing measurements (TEM, RH, THI, and wind). Nutrition, reproduction, and young stock questionnaire responses were analyzed as a binomial outcome variable (GLIMMIX procedure). Farm was used as a random effect. Region (NOR or SOU), stage of lactation (DRY or LACT), and their interaction were used as fixed effects and included in the model for the outcome variables: CS and TMR components (DM, CP, ADF, NDF, starch, sugar, Ca, P, Mg, K, S, Penn State Particle Separator), CSD, TMR apparent total-tract digestibility (DM and starch), PR, FSC, SC, and young stock housing measurements (TEM, RH, THI, and wind). The degrees of freedom method used was Kenward-Rogers (Littell et al., 1998).

Residual distribution was evaluated for normality and homoscedasticity. Extreme outliers (response variable observations that have either positive or negative extreme residual values) were excluded for CSD (n = 1), TMR starch (n = 1), TMR Penn State Particle Separator 0.78-cm sieve (n = 4), TMR Penn State Particle Separator pan (n = 1), manure DM (n = 3), and SC (n = 1). To meet criteria for normality and homoscedasticity, data were log-transformed (TMR sugar, TMR Penn State Particle Separator 1.9-cm sieve, manure starch, and wind speed) and inverse transformed (TMR Penn State box 0.4 cm). Data for the Penn State Particle Separator 1.9- and 0.4-cm-sieve data in Table 5 are presented back transformed. Statistical significance was declared as $P < 0.05$, and a tendency was declared as $0.05 < P < 0.10$.

RESULTS AND DISCUSSION

The aims of this study were to identify nutritional, reproductive, and young stock management characteristics in Illinois dairy farms and to identify potential geographical differences between the northern and southern regions in Illinois. We postulated that gathering information on important performance indexes would reveal differences between farms in northern and southern regions of Illinois.

Table 2. Means and associated SD for milk production analysis done in the last test before the visit, and yearly values in northern (n = 5) and southern farms (n = 12) in Illinois

	Region							
	North (n = 1,396 cows)				South (n = 5,409 cows)			
Variable	Mean	Median	SD	Range	Mean	Median	SD	Range
Number of lactating cows[1]	413	451	192	139–669	451	148	949	60–3,444
DIM[1]	187	191	17	160–209	203	194	22	174–246
Milk yield,[1] kg/d	37.9	41.6	6.7	26.1–41.9	33.8	32.91	5.7	23.4–43.5
Tank protein concentration,[1] %	3.18	3.00	0.35	3.00–3.80	3.08	3.05	0.21	2.80–3.50
Tank fat concentration,[1] %	3.88	3.60	0.75	3.40–5.20	3.56	3.40	0.43	3.10–4.30
SCC/mL[2]	196	189	21	172–219	207	182	109.3	102–526
SCC score[3]	2.64	2.60	0.25	2.3–3.0	2.50	2.45	0.49	1.80–3.50
Yearly average milk yield, kg/d	36.7	39.51	5.2	27.9–40.8	32.7	32.9	5.71	21.5–41.0
Tank yearly protein concentration, %	3.24	3.10	0.32	3.00–3.80	3.17	3.1	0.19	3.00–3.70
Tank yearly fat concentration, %	3.94	3.80	0.62	3.40–5.00	3.73	3.7	0.51	2.90–4.70
Tank yearly protein concentration, %	3.94	3.1	0.62	3.00–3.80	3.73	3.1	0.51	2.90–4.70
Tank yearly fat concentration, %	3.24	3.80	0.32	3.40–5.00	3.17	3.7	0.19	3.00–3.70
Yearly SCC[2]	193	208	37	136–231	236	219	79	113–409
Yearly SCC score[3]	2.64	2.60	0.32	2.20–3.10	2.66	2.65	0.43	1.90–3.50

[1]Last test date related to the team's visit.

[2]SCC = SCC × 1,000.

[3]SCC score = linear SCS.

In turn, identification of regional differences might lead to more specific and effective educational and extension programming.

Student Training

Extension programs as part of the land-grant university system promote new knowledge and its further use accomplished through research-based information (Chase et al., 2006). As farms consolidate, fewer students can have a hands-on farm background. The Dairy Focus Team experience allowed students to develop critical thinking and evaluation skills and bring greater depth to their understanding of their role as an animal scientist and their identity as an animal scientist. At the end of this training,

Table 3. Multivariate logistic mixed model of questions related to the farm herd nutrition characteristics from northern (NOR) and southern (SOU) farms in Illinois

Variable	Level	Coefficient	SE	OR[1]	CL[2]	*P*-value
Overall[3]						
Whether the farm measures DMI[4]	No	−0.22	0.26	0.80	0.09–7.24	0.83
Numbers of rations currently used[5]	≤2 Rations	0.18	1.33	1.20	0.07–19.84	0.89
Whether the farm pushs up feed[6]	No	−1.02	0.33	0.36	0.03–4.76	0.42
How long it takes to deliver feed[7]	>2 h	0.98	0.25	2.67	0.31–22.76	0.34
Whether the farm weighs back refusals[8]	No	−1.61	0.23	0.20	0.02–1.81	0.14
Farm target refusals[9]	≤2%	1.89	1.22	6.67	0.51–86.74	0.13
Whether the farm shakes TMR in the Penn State box[10]	No	−0.98	0.42	0.37	0.04–3.20	0.35
How many varieties were used?[11]	>2	0.12	0.14	1.12	0.12–10.40	0.91
Was the corn kernel processed?[12]	No	0.09	0.28	1.10	0.06–18.52	0.94
NOR						
Whether the farm measures DMI[4]	No	0.69	0.87	1.99	0.22–18.54	0.46
Numbers of rations currently used[5]	≤2 Rations	−1.61	1.09	0.20	0.01–3.35	0.20
Whether the farm pushs up feed[6]	No	−1.61	1.09	0.20	0.01–3.35	0.20
How long it takes to deliver feed[7]	>2 h	0.69	0.87	1.99	0.22–18.54	0.46
Whether the farm weighs back refusals[8]	No	−0.69	0.87	0.50	0.05–4.62	0.46
Farm target refusals[9]	≤2%	1.61	1.09	5.00	0.30–83.10	0.20
Whether the farm shakes TMR in the Penn State box[10]	No	−0.69	0.87	0.50	0.05–4.62	0.46
How many varieties were used?[11]	>2	−0.69	0.87	0.50	0.05–4.62	0.46
Was the corn kernel processed?[12]	No	−1.61	1.09	0.20	0.01–3.35	0.20
SOU						
Whether the farm measures DMI[4]	No	0.91	0.59	2.48	0.70–8.94	0.14
Numbers of rations currently used[5]	≤2 Rations	−1.79	0.76	0.17	0.03–0.87	0.03
Whether the farm pushs up feed[6]	No	−0.58	0.56	0.56	0.17–1.86	0.31
How long it takes to deliver feed[7]	>2 h	−0.29	0.54	0.75	0.23–2.41	0.60
Whether the farm weighs back refusals[8]	No	0.91	0.59	2.48	0.70–8.94	0.14
Farm target refusals[9]	≤2%	−0.29	0.54	0.75	0.23–2.41	0.60
Whether the farm shakes TMR in the Penn State box[10]	No	0.29	0.54	1.34	0.41–4.26	0.60
How many varieties were used?[11]	>2	−0.81	0.60	0.44	0.12–1.63	0.20
Was the corn kernel processed?[12]	No	−1.70	0.77	0.18	0.03–0.98	0.04

[1]If referent has same odds of success as level: odds ratio (OR) = 1. If referent has greater odds of success than level: OR >1. If referent has reduced odds of success than level, OR <1.

[2]CL = OR 95% confidence limit.

[3]Difference of regions least squares means.

[4]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 14; yes (referent) = 4, and no = 10].

[5]NOR [n = 6; >2 rations (referent) = 5, and ≤2 rations = 1] and SOU [n = 14; >2 rations (referent) = 2, and ≤2 rations = 12].

[6]NOR [n = 6; yes (referent) = 5, and no = 1] and SOU [n = 14; yes (referent) = 9, and no = 5].

[7]NOR [n = 6; ≤2 h (referent) = 2, and >2 h = 4] and SOU [n = 14; ≤2 h (referent) = 8, and >2 h = 6].

[8]NOR [n = 6; yes (referent) = 4, and no = 2] and SOU [n = 14; yes (referent) = 4, and no = 10].

[9]NOR [n = 6; >2% refusals (referent) = 1, and ≤2% refusals = 5] and SOU [n = 14; >2% refusals (referent) = 8, and ≤2% refusals = 6].

[10]NOR [n = 6; yes (referent) = 4, and no = 1] and SOU [n = 14; yes (referent) = 6, and no = 8].

[11]NOR [n = 6; >2 hybrids (referent) = 2, and ≤2 hybrids = 4] and SOU [n = 14; >2 hybrids (referent) = 4, and ≤2 hybrids = 10].

[12]NOR [n = 6; yes (referent) = 5, and no = 1] and SOU [n = 13; yes (referent) = 11, and no = 2].

students were able to understand real-world situations in the dairy industry, they increased their ability to work in a group as a team, and they developed practical implementations that could be implemented on farm by extrapolating their classroom instruction to use in a real-world setting. One student reported: "Following my sophomore year, I worked at a dairy farm near my hometown. I was able to implement some of my learning from this program and suggest some ways to improve the farm's herd management in order to increase production and better herd health." Furthermore, students were able to highlight and write about the topics in a newsletter format (http://dairyfocus.illinois.edu/content/dairy-focus-newsletter).

Nutrition

The questionnaire description is detailed in Table 1. Results for the nutrition section of the questionnaire are in Table 3. There were no differences between NOR and SOU for questions related to herd nutrition. Producers in SOU had reduced odds [odds ratio (**OR**) = 0.17, $P = 0.03$] of feeding ≤2 different rations to the herd than feeding >2 rations to the herd. It is widely known that offering specific rations for different stages of lactation has the potential to increase efficiency and productivity, and to reduce feed costs (Zwald and Shaver, 2012). According to Maltz et al. (2013), cows can increase their milk production by 3.2 kg/d when fed according to their energy requirements. Contreras-Govea et al. (2015) reported that the number of dairy farms that grouped cows according to their nutritional requirements in the upper Midwest is unknown. Our results showed that SOU had greater odds for feeding more than 2 different rations to the herd; this may indicate that their income over feed costs could be greater than those farms not feeding >2 different rations to the herd (Cabrera et al., 2012).

Analyses of CS are in Table 4. The phosphorus concentrations were 0.21 ± 0.009 and 0.17 ± 0.006% on a DM basis for NOR and SOU, respectively ($P = 0.003$). Corn silage density was 168.5 ± 12.2 and 221.2 ± 8.2 kg/m^3 for NOR and SOU, respectively ($P = 0.003$). Also, SOU had reduced odds (OR = 0.18, $P = 0.03$) for CS not being kernel processed than CS being kernel processed. Studies on bunker silo packing (Muck and Holmes, 2006) showed that larger particle size might imply reduced density. Density tends to decrease as particle size increases at 4.1 kg of DM/m^3 per millimeter of increased length (Muck and Holmes, 2006). A potential explanation for CSD differences between NOR and SOU could be variation in bagging machines and operators (Muck and Holmes, 2006). A greater CSD is always preferable because it prevents air infiltration and further storage losses because of the CS oxidation. Also, a greater CSD reduces the cost of storage because it is possible to have more DM stored in a given volume (D'Amours and Savoie, 2005). Although Muck and Holmes (2006) indicated that unprocessed CS was consistently denser than processed silage, SOU Illinois had greater odds for processing CS.

Table 4. Least squares means and associated SE for corn silage analyses,[1] and particle size characterization in northern and southern Illinois

	Region			
Variable	North (n = 5)	South (n = 12)	SE	*P*-value
DM, %	38.7	37.2	2.0	0.45
CP, % of DM	9.7	9.1	0.32	0.06
ADF, % of DM	21.9	21.4	1.2	0.70
NDF, % of DM	35.8	35.5	1.9	0.88
P, % of DM	0.21	0.17	0.01	0.0035
K, % of DM	1.40	1.31	0.13	0.50
Starch, % of DM	33.9	37.0	2.6	0.29
Sugar, % of DM	1.79	1.36	0.30	0.19
Ca, % of DM	0.26	0.20	0.03	0.11
Mg, % of DM	0.15	0.11	0.01	0.04
PS[2] 1.9 cm	11.8	7.1	2.2	0.08
PS[2] 0.78 cm	61.7	60.0	3.8	0.67
PS[2] 0.40 cm	16.7	20.9	3.5	0.24
PS[2] bottom pan	9.8	12.0	3.5	0.55
Density,[3] kg/m^3	168	221	12	0.003

[1]A total of 17 samples were analyzed (one sample per farm).

[2]Penn State particle size analyses.

[3]Density: north (n bag = 2, n pile = 2); south (n bag = 7, n pile = 4).

Results of TMR analyses are in Table 5. Although DM content did not differ with lactation stage (LACT or DRY), there was a region × stage interaction ($P = 0.006$) and effect of region ($P = 0.02$). The CP was greater ($P = 0.0004$) for TMR offered to LACT (16.1 ± 0.4%) than the one offered to DRY (12.4 ± 1.6%) in both regions. Acid detergent fiber, NDF, and P concentrations were greater ($P < 0.0001$) for TMR offered to DRY than TMR offered to LACT in both regions (Table 5). Starch concentration was greater ($P < 0.0001$) in TMR offered to LACT (25.4 ± 0.8%) than in those offered to DRY (12.8 ± 1.9%); there was also a tendency ($P = 0.07$) for a region × stage interaction. Calcium concentration was greater ($P < 0.03$) in TMR offered to LACT (0.78 ± 0.04%) than in those offered to DRY (0.58 ± 0.08%). Magnesium concentration in the TMR offered to both LACT and DRY was greater ($P = 0.007$) for NOR (0.34 ± 0.02%) than SOU (0.26 ± 0.01%). Although the top sieve of the particle size distribution (1.9 mm) did not differ between regions, there was a stage effect ($P = 0.05$). Apparent total-tract starch digestibility was 96.0 ± 0.9 and 98.7 ± 2.1% for LACT and DRY, respectively, in NOR and 96.8 ± 0.6 and 97.26 ± 1.2% for LACT and DRY, respectively, in SOU ($P = 0.89$). The DM of manure was greater for SOU (15 ± 0.4%) than NOR (13.5 ± 0.6%, $P = 0.05$). Manure starch was 3.23 ± 0.7 and 1.00 ± 1.7% for LACT and DRY, respectively, in NOR and 2.6 ± 0.5 and 2.23 ± 0.99% for LACT and DRY, respectively, in SOU ($P = 0.87$).

Although TMR top sieve particle size distribution (1.9 mm) did not differ between regions, both regions showed greater proportions (>10%) than recommended by Kononoff et al. (2003). Cows tend to select against greater fiber components of the diet and in favor of smaller concentrate particles (Leonardi and Armentano, 2003). Feeding a nutritionally balanced diet to cows has always been a challenge (Sova et al., 2014). In addition, not grouping cows according to their nutritional requirements may exacerbate dominance problems and increase sorting to the detriment of their health, by potentially increasing the risk for subacute ruminal acidosis in dominant cows (Hosseinkhani et al., 2008).

Reproduction

Analyses of the reproduction section of the questionnaire are in Table 6. The NOR had greater odds (OR = 12.0, $P = 0.04$) of knowing the percentage of dystocia of

Table 5. Least squares means and associated SE for TMR and particle size characterization of the TMR in northern farms (n = 5) and southern farms (n = 14) in Illinois, by region and by lactation stage

	Region							*P*-value		
	North			South						
Variable	Lactating[2]	Dry[3]	Overall[4]	Lactating[5]	Dry[6]	Overall[7]	SE	Region	Stage[1]	Region × Stage[1]
DM, %	46.2	51.2	48.7	47.3	40.8	44.1	3.2	0.02	0.71	0.006
CP, % of DM	16.5	12.4	14.4	17.2	13.3	15.2	1.6	0.44	0.0004	0.91
ADF, % of DM	22.8	37.6	30.2	24.4	32.6	28.5	3.0	0.38	<0.0001	0.09
NDF, % of DM	33.8	56.5	45.1	38.2	50.9	44.6	3.1	0.78	<0.0001	0.01
P, % of DM	0.41	0.30	0.36	0.38	0.33	0.35	0.04	0.97	0.0007	0.24
K, % of DM	1.52	1.55	1.54	1.50	1.12	1.31	0.18	0.04	0.12	0.07
Starch, % of DM	26.8	10.3	18.6	24.1	15.2	19.7	3.3	0.59	<0.0001	0.07
Sugar, log-transformed, % of DM	0.90	1.00	0.95	0.87	0.75	0.81	0.17	0.20	0.92	0.29
Ca, % of DM	0.86	0.54	0.70	0.70	0.62	0.66	0.08	0.69	0.03	0.20
Mg, % of DM	0.32	0.37	0.34	0.26	0.27	0.26	0.04	0.007	0.28	0.49
PS[8] 1.9 cm	11.4	20.2	15.8	11.0	13.8	12.4	4.0	0.26	0.05	0.32
PS[8] 0.78 cm	44.7	42.0	43.3	36.5	37.3	36.9	2.9	0.005	0.68	0.44
PS[8] 0.40 cm	17.9	16.7	17.3	19.1	22.1	20.6	3.1	0.17	0.69	0.37
PS[8] bottom pan	25.1	21.1	23.1	32.4	22.8	27.6	4.4	0.18	0.04	0.40

[1]Stage: TMR lactating and dry samples.

[2]TMR lactating samples: n = 11.

[3]TMR dry samples: n = 2.

[4]Overall: TMR lactating and dry samples: n = 13.

[5]TMR lactating samples: n = 28.

[6]TMR dry samples: n = 6.

[7]Overall: TMR lactating and dry samples: n = 34.

[8]Penn State particle size analysis.

Table 6. Multivariate logistic mixed model of questions related to the farm herd reproduction characteristics from northern (NOR) and southern (SOU) farms in Illinois

Variable	Level	Coefficient	SE	OR[1]	CL[2]	*P*-value
Overall[3]						
Whether the percentage of dystocia was known[4]	No	2.48	1.15	12.00	1.06–135.7	0.04
Whether the percentage of abortion was known[5]	No	0.40	1.02	1.50	0.18–12.80	0.69
Whether the percentage of dead on arrival was known[6]	No	0.98	1.02	2.67	0.31–22.76	0.35
Average of days open[7]	>150	0.56	1.46	1.75	0.07–45.66	0.71
Whether the actual calving interval was known[8]	No	−0.10	1.03	0.90	0.10–7.84	0.92
Whether the farm breeding program uses any type of hormone[9]	No	0.61	1.08	1.83	0.19–17.86	0.58
Farm voluntary waiting period[10]	>60	0.18	1.33	1.20	0.07–19.84	0.89
Whether the farm uses bulls for clean up[11]	No	0.98	1.02	2.67	0.31–22.76	0.35
Whether the metabolic problems are identified[12]	No	0.95	1.51	2.60	0.11–61.90	0.53
Whether the farm records calving scores[13]	No	0.22	1.05	1.25	0.14–11.32	0.84
NOR						
Whether the percentage of dystocia was known[4]	No	0.69	0.87	1.99	0.22–18.54	0.45
Whether the percentage of abortion was known[5]	No	0.69	0.87	1.99	0.22–18.54	0.45
Whether the percentage of dead on arrival was known[6]	No	0.69	0.87	1.99	0.22–18.54	0.45
Average of days open[7]	>150	−0.69	1.22	0.5	0.00–97.51	0.63
Whether the actual calving interval was known[8]	No	−0.69	0.87	0.5	0.05–4.62	0.46
Whether the farm breeding program uses any type of hormone[9]	No	−0.69	0.87	0.5	0.05–4.62	0.46
Farm voluntary waiting period[10]	>60	−1.61	1.01	0.20	0.01–3.35	0.20
Whether the farm uses bulls for clean up[11]	No	0.69	0.87	1.99	0.22–18.54	0.45
Whether the metabolic problems are identified[12]	No	−1.61	1.01	0.20	0.01–3.35	0.20
Whether the farm records calving scores[13]	No	−0.69	0.87	1.99	0.05–4.62	0.46
SOU						
Whether the percentage of dystocia was known[4]	No	−1.79	0.76	0.17	0.03–1.15	0.03
Whether the percentage of abortion was known[5]	No	0.28	0.54	1.32	0.41–4.26	0.60
Whether the percentage of dead on arrival was known[6]	No	−0.28	0.54	0.76	0.23–2.41	0.60
Average of days open[7]	>150	−1.25	0.80	0.29	0.05–1.80	0.16
Whether the actual calving interval was known[8]	No	−0.59	0.56	0.55	0.17–1.86	0.31
Whether the farm breeding program uses any type of hormone[9]	No	−1.29	0.65	0.27	0.07–1.12	0.06
Farm voluntary waiting period[10]	>60	−1.79	0.76	0.17	0.03–1.15	0.03
Whether the farm uses bulls for clean up[11]	No	−0.28	0.54	0.76	0.23–2.41	0.60
Whether the metabolic problems are identified[12]	No	−2.56	1.04	0.08	0.01–1.38	0.03
Whether the farm records calving scores[13]	No	−0.92	0.59	0.40	0.11–1.43	0.03

[1]If referent has same odds of success as level: odds ratio (OR) = 1. If referent has greater odds of success than level: OR >1. If referent has reduced odds of success than level, OR <1.

[2]CL = OR 95% confidence limit.

[3]Difference of regions least squares means.

[4]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 14; yes (referent) = 12, and no = 2].

[5]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 14; yes (referent) = 6, and no = 8].

[6]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 14; yes (referent) = 8, and no = 6].

[7]NOR [n = 3; ≤150 (referent) = 2, and >150 = 1] and SOU [n = 9; ≤150 (referent) = 7, and >150 = 2].

[8]NOR [n = 6; yes (referent) = 4, and no = 2] and SOU [n = 14; yes (referent) = 9, and no = 5].

[9]NOR [n = 6; yes (referent) = 4, and no = 2] and SOU [n = 14; yes (referent) = 11, and no = 3].

[10]NOR [n = 6; ≤60 (referent) = 5, and >60 = 1] and SOU [n = 14; ≤60 (referent) = 12, and >60 = 2].

[11]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 14; yes (referent) = 8, and no = 6].

[12]NOR [n = 6; yes (referent) = 5, and no = 1] and SOU [n = 14; yes (referent) = 13, and no = 1].

[13]NOR [n = 6; yes (referent) = 4, and no = 2] and SOU [n = 14; yes (referent) = 10, and no = 4].

Table 7. Multivariate logistic mixed model of questions related to the farm young stock characteristics from northern (NOR) and southern (SOU) farms in Illinois

Variable	Level	Coefficient	SE	OR[1]	CL[2]	*P*-value
Overall[3]						
When is the largest percentage of calf deaths?[4]	>1 wk	2.49	1.15	12.00	1.06–135.74	0.04
How much colostrum does each calf get?[5]	≤3.78 L	−1.32	1.22	0.27	0.02–3.47	0.29
How much milk is fed per day?[6]	≤3.78 L	−0.95	1.51	0.38	0.01–9.16	0.53
How many times is milk offered per day?[7]	≤Twice/d	−0.95	1.51	0.38	0.01–9.16	0.53
Temperature that milk is mixed[8]	≤40°C	−2.39	1.16	0.09	0.01–1.05	0.05
How long does it take to get the milk to the calf?[9]	>15 min	−0.31	1.27	0.73	0.05–10.67	0.81
Milk adjustment depending on time of the year[10]	No	1.02	1.23	2.78	0.21–36.75	0.42
When is starter offered?[11]	≤1 wk	−1.09	1.15	0.33	0.02–3.77	0.35
Whether starter intake is estimated[12]	No	−0.12	1.05	0.89	0.09–8.22	0.91
How often is water changed?[13]	≤Twice/d	0.40	1.28	1.50	0.10–22.24	0.75
Age of the calf when weaned[14]	>6 wk	1.14	1.23	0.32	0.23–42.30	0.37
Whether the farm has a vaccination protocol[15]	No	0.22	1.04	0.80	0.14–11.32	0.84
NOR						
When is the largest percentage of calf deaths?[4]	>1 wk	0.69	0.87	1.99	0.22–18.54	0.46
How much colostrum does each calf get?[5]	≤3.78 L	−1.61	1.09	0.20	0.01–3.35	0.20
How much milk is fed per day?[6]	≤3.78 L	1.61	1.09	5.00	0.30–83.10	0.20
How many times is milk offered per day?[7]	≤Twice/d	1.61	1.09	5.00	0.30–83.10	0.20
Temperature that milk is mixed[8]	≤40°C	−0.69	0.87	0.50	0.05–4.62	0.46
How long does it take to get the milk to the calf?[9]	>15 min	−1.61	1.09	0.20	0.01–3.35	0.20
Milk adjustment depending on time of the year[10]	No	1.61	1.09	5.00	0.30–83.10	0.20
When is starter offered?[11]	≤1 wk	0.69	0.87	1.99	0.22–18.54	0.46
Whether starter intake is estimated[12]	No	0.69	0.87	1.99	0.22–18.54	0.46
How often is water changed?[13]	≤Twice/d	1.61	1.09	5.00	0.30–83.10	0.20
Age of the calf when weaned[14]	>6 wk	1.61	1.09	5.00	0.30–83.10	0.20
Whether the farm has a vaccination protocol[15]	No	−0.69	0.87	0.50	0.05–4.62	0.46
SOU						
When is the largest percentage of calf deaths?[4]	>1 wk	−1.79	0.76	0.17	0.03–1.15	0.03
How much colostrum does each calf get?[5]	≤3.78 L	−0.29	0.54	0.75	0.23–2.41	0.60
How much milk is fed per day?[6]	≤3.78 L	2.56	1.03	12.94	1.38–122.73	0.02
How many times is milk offered per day?[7]	≤Twice/d	2.56	1.03	12.94	1.38–122.73	0.02
Temperature that milk is mixed[8]	≤40°C	1.70	0.77	5.47	1.03–29.37	0.04
How long does it take to get the milk to the calf?[9]	>15 min	−1.29	0.65	0.27	0.01–1.12	0.06
Milk adjustment depending on time of the year[10]	No	0.59	0.56	1.80	0.54–5.99	0.31
When is starter offered?[11]	≤1 wk	1.79	0.76	5.99	0.03–1.15	0.03
Whether starter intake is estimated[12]	No	0.82	0.60	2.27	0.61–8.33	0.20
How often is water changed?[13]	≤Twice/d	1.20	0.66	3.32	0.79–14.01	0.65
Age of the calf when weaned[14]	>6 wk	0.47	0.57	1.60	0.46–5.53	0.42
Whether the farm has a vaccination protocol[15]	No	−0.92	0.59	0.40	0.11–1.43	0.14

[1]If referent has same odds of success as level: odds ratio (OR) = 1. If referent has greater odds of success than level: OR >1. If referent has reduced odds of success than level, OR <1.

[2]CL = OR 95% confidence limit.

[3]Difference of regions least squares means.

[4]NOR [n = 6; ≤first wk of life (referent) = 1, and >first wk of life = 5] and SOU [n = 14; ≤first wk of life (referent) = 6, and >first wk of life = 8].

[5]NOR [n = 6; >3.78 L (referent) = 2, and ≤3.78 L = 4] and SOU [n = 14; >3.78 L (referent) = 2, and ≤3.78 L = 12].

[6]NOR [n = 6; >3.78 L (referent) = 5, and ≤3.78 L = 1] and SOU [n = 14; >3.78 L (referent) = 13, and ≤3.78 L = 1].

[7]NOR [n = 6; >twice/d (referent) = 5, and >twice/d = 1] and SOU [n = 14; >twice/d (referent) = 13, and ≤twice/d = 1].

[8]NOR [n = 6; >40°C (referent) = 2, and ≤40°C = 4] and SOU [n = 13; >40°C (referent) = 11, and ≤40°C = 2].

[9]NOR [n = 3; ≤15 min (referent) = 5, and >15 min = 1] and SOU [n = 14; ≤15 min (referent) = 11, and >15 min = 3].

[10]NOR [n = 6; yes (referent) = 1, and no = 5] and SOU [n = 14; yes (referent) = 5, and no = 9].

[11]NOR [n = 6; >1 wk of life (referent) = 4, and ≤1 wk of life = 2] and SOU [n = 14; >1 wk of life (referent) = 12, and ≤1 wk of life = 2].

[12]NOR [n = 6; yes (referent) = 2, and no = 4] and SOU [n = 13; yes (referent) = 4, and no = 9].

[13]NOR [n = 6; >twice/d (referent) = 1, and >twice/d = 5] and SOU [n = 13; >twice/d (referent) = 3, and ≤twice/d = 10].

[14]NOR [n = 6; ≤6 wk of life (referent) = 1, and >1 wk of life = 5] and SOU [n = 13; ≤1 wk of life (referent) = 5, and >6 wk of life = 8].

[15]NOR [n = 6; yes (referent) = 4, and no = 2] and SOU [n = 14; yes (referent) = 10, and no = 14].

the herd than for not knowing the percentage of dystocia of the herd. There were reduced odds (OR = 0.17, P = 0.03) for having a voluntary waiting period >60 d than a voluntary waiting period ≤60 d in SOU. The SOU had reduced odds (OR = 0.08, P = 0.03) for not identifying the most prevalent metabolic problems at the farm than for identifying the metabolic problems. Pregnancy rate was different for NOR than SOU (19.8 ± 2.2 vs. 12.6 ± 1.6, P = 0.02). Overall SC was different for cows and heifers (2.63 ± 0.11 vs. 1.76 ± 0.12, P < 0.0001) and for NOR and SOU (2.50 ± 0.13 vs. 1.88 ± 0.10, P = 0.001).

Greater milk production per cow has been associated with reduced reproductive performance. According to Giordano et al. (2011), reduced apparent reproductive performance could be because of management improvements, such as improved reports. LeBlanc (2010) concluded that the most popular reproductive performance measurements were either incomplete or biased. In our study, there was a mathematical but not statistical difference between NOR and SOU; cows in NOR were numerically producing more milk per day than cows in SOU. Also, PR was 7.2 points greater for NOR than SOU, and SC was 0.61 greater in NOR. Researchers stated that dairy cow reproductive performance is not only highly affected by intensive selection for milk production, but also by management practices such as heat detection efficiency, nutrition, BCS, and udder health (Lucy, 2001; Caraviello et al., 2006; Schefers et al., 2010). Furthermore, SOU showed a tendency for reduced odds for not using hormones on their breeding programs. Voluntary waiting period can be controlled by using hormones on cow synchronization protocols and also can increase PR by decreasing AI service interval (Fricke et al., 2003).

Young Stock

Analyses of the young stock section are in Table 7. The NOR had greater odds (OR = 12.0, P = 0.04) than SOU for having the greatest percentage of calf deaths beyond the first week after birth than before the first week after birth; SOU showed reduced odds (OR = 0.17, P = 0.03) for having the greatest percentage of calf deaths beyond the first week after birth. The NOR had reduced odds (OR = 0.09, P = 0.05) than SOU for milk being mixed at a temperature ≤40°C than a temperature >40°C. The SOU had greater odds (OR = 12.94, P = 0.03) for feeding ≤3.78 L of milk/d to calves than feeding >3.78 L of milk/d. There were greater odds (OR = 12.94, P = 0.03) of offering milk to calves ≤2 times/d than offering milk to calves >2 times/d in SOU. There were greater odds (OR = 5.99, P = 0.03) for offering starter to calves before the first week after birth than offering it beyond the first week after birth in SOU. Ambient temperature was 27.5 ± 2.0 and 27.5 ± 1.0°C for young stock housed in NOR and SOU, respectively (P = 0.97). The RH was greater for SOU than NOR (62.6 ± 2.0 vs. 41.1 ± 4.0%; P < 0.0001).

Not surprisingly, SOU had reduced odds of having a greater percentage of calves dying after their first week of life because they were feeding less time per day and also feeding a smaller total amount of milk. Total amount of feed offered to calves should be adjusted according to weather conditions, calf health status, and BW. Maintenance of calves increases when the calf is exposed to conditions outside of the thermo-neutral zone (Beatty et al., 2006) and calves are forced to use energy reserves to maintain body temperature (Scibilia et al., 1987). The same authors reported that calves need 32% more energy when their body temperature is not in the thermo-neutral zone or their growth and immune system will be compromised. As a result total amount of feed offered to calves or the concentration of nutrients should be increased to meet the requirements for maintenance as well as the amount of energy and protein to meet targeted ADG (Scibilia et al., 1987).

IMPLICATIONS

Differences in nutritional, reproductive, and young stock management were identified between NOR and SOU. Farms in SOU were more proficient ensiling corn; their silos had greater CSD, implying reduced losses (e.g., CS oxidation) and costs (e.g., more DM stored with a given volume) than farms in NOR. The tendency for farms in SOU being less likely to use breeding programs could explain why they had reduced PR when compared with farms in NOR. Farms in NOR had more proficient feeding management strategies for calves than farms in SOU. These geographical differences should be considered by dairy farmers, policymakers, and the dairy industry to enable consistent improvement in production efficiency.

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