

EVALUATION OF BEST PRACTICES ASSOCIATED WITH ENHANCED
PERFORMANCE IN ILLINOIS DAIRY FARMS: A DAIRY FOCUS TEAM APPROACH

BY

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THESIS

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ABSTRACT

It is expected that, by the year 2030, the world will have approximately 9.3 billion inhabitants, and by the year 2050 more productive agricultural land would be required to cover the extra 70 to 100% food needed. Although more land would be required, the world would be facing land deficiency since in the last decades higher proportions of good quality land has been allocated to human purposes (e.g. urbanization, emerging generation of biofuels) or lost because of environmental problems (e.g. climate change, desertification, and soil erosion). In an effort to improve efficiency and milk production, the U.S. dairy industry has faced several changes over the last years. During the last three decades milk production increased 59.4% and the total number of dairy cows and operations decreased 17% and 74%, respectively. Improvements in genetic selection and cow nutrition have helped dairy farms to keep dairy farms profitability by increasing average milk yield per cow and average herd size. Illinois' average herd size and average milk yield per cow increased 39.7% and 28%, respectively, from 1991 to 2006. On the other hand, IL total number of dairy operations decreased almost 57%, and the total number of licensed operations (grade A or B) decreased approximately 18% from 2002 to 2006. Therefore, the objectives of this study were to identify nutritional, reproductive, young stock, and on-farm practices associated with milk quality in IL dairy farms; and to study potential geographical differences between the North (N) and South (S) regions in IL. Both objectives could help IL dairy farmers to improve their operations' performance.

For the purpose of this study, 20 dairy farms, located in N (n = 6) and S (n 14) were visited by the Dairy Focus Team. The Dairy Focus Team is made up of a CEO, a president, dairy mentors (e.g., faculty and industry members), and five graduate students that serve as chairmen. Each chairman, helped by one or two graduate and undergraduate students, is in charge of one of the following sections: nutrition, management, milk quality, reproduction, and young stock. To standardize data collection, a questionnaire was developed. Also, five forms were developed in order to make data collection easier and to record specific information from each section (e.g., number of stalls on each pen, number of cows drinking on each pen). All students were trained on how to use these forms, and also on how to collect samples, and to record measurements (e.g., wind speed, relative humidity, and temperature). During the visits, a questionnaire, DHI records, and the individual farm dataset (PCDART, Dairy Comp 305, Dairy Plan, and AgriTech Analytics) were collected from May through June 2014. Also samples related to nutrition (e.g., corn silage, TMR), young stock, lactating (**LACT**), and dry (**DRY**) cows housing environmental measurements [relative humidity (**RH**), d wind speed measurements (**WS**), and ambient temperature], and cow comfort assessments about LACT and DRY cows were collected. Average herd size was 413 ± 192 and 451 ± 949 LACT for N and S regions, respectively. Average milk yield per cow/d was 37.9 ± 6.7 kg and 33.8 ± 5.7 kg for N and S, respectively.

The mean density of corn silage was higher for S than N (221.16 ± 8.24 vs 168.55 ± 12.22 kg/m³, respectively). Dry matter (**DM**) content of the TMR offered to both LACT and

DRY was higher for N than S (48.73 ± 1.72 vs. 44.06 ± 1.00 %, respectively). Yearly pregnancy rate (19.75 ± 2.19 vs. 12.57 ± 1.65 , respectively), and service per conception rate (2.5 ± 0.13 vs. 1.88 ± 0.10 , respectively) were higher for cows and heifers in N than S. A tendency for S for being less likely to use hormones in their breeding programs could explain why N had higher pregnancy rate (**PR**) than S. The RH percentage was higher for S than N (62.56 ± 2.05 vs. 41.08 ± 4.00 %, respectively). Southern IL had 12.93 time higher odds for calves being fed equal or less than 3.78 L of milk per day. Sand bedding quality was evaluated by quantifying DM and organic matter (**OM**) contents, as well as particle size distribution (**PS**). Lactating cows' bedding DM was 95.95 ± 0.49 % and 96.40 ± 0.35 % for N and S, respectively. Lactating cow's bedding OM was 3.08 ± 0.51 % and 2.61 ± 0.36 % for N and S, respectively. Average tank SCC was 196 ± 21 and 207 ± 109 for N and S, respectively. A higher OM content was found in DRY cows' bedding (5.36 ± 0.62) than LACT (2.85 ± 0.31). A linear association between OM and bulk tank SCC was found ($SCC = 133.75 + 15.00 \times OM$). Hence, surveillance of bedding OM used in dairy farms may improve herd milk quality.

In conclusion, there were nutritional, reproductive, young stock, and milk quality management differences between N and S. Farms in S were more efficient at the moment of ensiling their silos since higher CSD implies less losses (e.g., CS oxidation) and less costs (e.g., more DM stored with the same volume) than farms in N. Sand bedding DM content was higher for S than for N. Sand bedding OM content was higher for DRY cows than for LACT cows.

Organic matter content in the sand used for bedding in dairy farms was positively associated with bulk tank SCC. Surveillance of bedding OM used in dairy farms may improve herd milk quality (SCC). The geographical differences between N and S, hereby presented, have to be taken in consideration by dairy farmers, policymakers, and the dairy industry at large for consistent improvement in dairy farms' efficiency.

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Just then they came in sight of thirty or forty windmills that rise from that plain. And no sooner did Don Quixote see them that he said to his squire, "Fortune is guiding our affairs better than we ourselves could have wished. Do you see over yonder, friend Sancho, thirty or forty hulking giants? I intend to do battle with them and slay them. With their spoils we shall begin to be rich for this is a righteous war and the removal of so foul a brood from off the face of the earth is a service God will bless."

"What giants?" asked Sancho Panza.

"Those you see over there," replied his master, "with their long arms. Some of them have arms well-nigh two leagues in length."

"Take care, sir," cried Sancho. "Those over there are not giants but windmills. Those things that seem to be their arms are sails which, when they are whirled around by the wind, turn the millstone."

(Miguel de Cervantes, *The Ingenious Gentleman Don Quixote of La Mancha*)

Eleven years ago I decided to fight against “the giants” and follow my passion. This has been a long and not easy journey but walking down this winding pathway could not have been possible the support and love of each of the extraordinary people around me. And this is just the beginning, because a passion never ends.

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LIST OF ABBREVIATIONS

ADF	acid detergent fiber
BCS	body condition score
Ca	calcium
CP	crude protein
CS	corn silage
CSD	corn silage density
d	day(s)
DIM	days in milk
DM	dry matter
DRY	dry cows
FSC	first service per conception rate
h	hour(s)
HS	hock score
Ig	immunoglobulins
IL	Illinois
K	potassium
L	liter(s)

LS	lameness score
LACT	lactating cows
LLS	lower leg score
min	minutes
Mg	magnesium
N	Northern Illinois
NDF	neutral detergent fiber
OM	organic matter
P	phosphorus
PR	pregnancy rate
PG	particle per gram
PSD	particle size distribution
PTD	previous milk test day
RH	relative humidity
S	Southern Illinois
SC	service per conception rate
SCC	somatic cell counts
SCCS	somatic cell counts score
T	temperature

TD	test date
THI	temperature humidity index
THS	teat hygiene score
TMR	total mixed ration
UHS	udder hygiene score
ULS	upper leg score
US	United States of America
VDS	vaginal discharge
wk	week(s)
WS	wind speed

CHAPTER I. LITERATURE REVIEW

WORLD DAIRY INDUSTRY

Although more productive agricultural land would be required to cover the extra 70 to 100% food that the world will need by the year 2050, this land has been allocated to human purposes such as urbanization in the last decades (Baulcombe et al., 2009; Godfray et al., 2010). In addition, factors like climate change, desertification, soil erosion, and the emerging generation of biofuels on good quality agricultural land would add an extra problem to land deficiency (Solomon et al., 2007; Nellemann, C. 2009). According to Nakicenovic and Swart (2000), it is projected that the world population will be around 9.3 billion inhabitants by the year 2030. It is expected that livestock products consumption per capita will be around 45.3 kg per year and milk consumption will be approximately 89.5 kg per capita per year by the year 2030 (WHO, 2003). Consequently, it will be necessary to find solutions to face this growth in food consumption by using the same or less amount of good quality land (Godfray et al., 2010).

Dairy and dairy products, an important worldwide source of food, are no exception to this world food production challenge (De Vliegher et al., 2012). During the past 30 years, milk production increments happened thanks to improvements in mixed and industrial systems and much less so in grazing systems (Bouwman et al., 2005). Ruminant production showed an accelerated increment of 40% during 1970 to 1995 compared with grassland world area that increased at a slower rate of 4 % (FAO, 2011). About 9.8 million ha of the land intended for

crops has shifted to corn production to supply the 136 billion liters of ethanol that the U.S. Energy Independence and Security Act required by the year 2022 (Pimentel et al., 2009; CAST, 2012).

In an effort to improve efficiency and milk production, the U.S. dairy industry has faced several changes over the last years (Table 1.1, Table 1.2, and Figure 1.2). However, the total number of dairy cows and operations decreased 17% and 74% respectively; milk production increased 59.4% during the last three decades (Chase et al., 2006). Improvements in genetic selection and cow nutrition have helped dairy farms to maintain profitability by increasing average milk yield per cow and average herd size (Lucy, 20001; De Vlieghe et al., 2012). Under the same scenario, Illinois' average herd size and average milk yield per cow increased 39.7% and 28%, respectively, from 1991 to 2006. On the other hand, IL total number of dairy operations decreased almost 57%, and the total number of licensed operations (grade A or B) decreased approximately 18% from 2002 to 2006 (USDA, 2008). Currently, IL has a total of 703 dairy farms of which 662 are Grade A and 41 are manufacturing grade dairy farms (Figure 1.2 and Figure 1.3).

The dairy industry faces a complex scenario in which consumers are looking for cheaper food (Appleby et al., 2003), but at the same time it has to have better quality and has to support their personal values. Although consumers claim that food safety is their priority (Vanhonacker et al., 2010; Ingenbleek and Immink 2011), they still choose prices over quality when purchasing

food (Harvey and Hubbard, 2013). On the other hand, milk is considered as a commodity (Von Keyserlingk et al., 2013), especially since mid-2000 when the U.S. started exporting more milk thanks to growing demands from China and to the diminution of production subsidies in the EU (Nicholson and Stephenson, 2012). Hence, dairy farmers need to find a suitable management strategy to allow them to reduce their cost of production and thereby increase profits (Von Keyserlingk et al., 2013).

NUTRITION

Dairy feeding programs have the objective of feeding the adequate nutritional balance to assure rumen health and to maximize feed intake, reproductive efficiency, and profitability (VandeHaar et al., 2012). Total mixed rations were originated as a necessity for dairy farms to reduce costs associated with feed and also to ensure an optimal digestive function by delivering a homogeneous nutrient source to cows (Coppock et al., 1981). The TMR that are delivered and that cows are actually eating are not always the same that was originally formulated. In order to maximize cows' performance, their rations must have a physical and chemical constancy (Sova et al., 2014). Although TMR variability affects dairy farm efficiency and profitability (Mikus, 2012), is practically inevitable to have these variances in ration composition (Stone, 2008). Factors that can lead to TMR consistency differences are nutrient variability, the order in which the ingredients are mixed (Mikus, 2012), and feed bunk design (Huzzey et al. 2006).

Researchers showed that diets consumed by cows often have a higher concentration of fermentable carbohydrates than effective fiber proportions because of sorting (Leonardi and Armentano, 2003; DeVries et al., 2005). When cows are competing for space at the feed bunk they usually do not get the same rations since subordinate cows tend to be displaced by dominant cows (Hosseinkhani et al. 2008). Hence, ruminal acidosis risk increases when cows have access to inconsistent rations or they can sort their feed (DeVries et al., 2008). Sova et al. (2013) pointed that efficiency can be enhanced by different feeding management such as improving feed access space or increasing feeding frequency. Furthermore, grouping cows according to their nutrient requirements could be beneficial to the environment by minimizing nitrogen and phosphorus excretion (Zwald and Shaver 2012; Maltz et al., 2013) and also to farmers by avoiding associated cost of overfeeding phosphorus or nitrogen (Wu et al., 2000; Rotz et al., 2002). Although researchers have proved the benefits of regrouping lactating cows according to their nutrient requirements (Cabrera et al., 2012; VandeHaar et al., 2012; Contreras -Govea, et al., 2015), dairy farmers and nutritionists are still discussing whether or not to do so (Zwald and Shaver 2012). A survey done by Contreras-Govea et al. (2015) highlighted that “desire to keep it simple” and “milk drops when cows are moved to a different group ” are some of the reasons given by dairy farmers still not feeding more than one diet. Contrary to these thoughts, Zwald and Shaver (2012) showed that average milk yield drops on the first day and then return to its baseline on the second day after cows were moved.

Changes in the dairy industry led to a milk increment of 59% with fewer cows, which consume about 77% less feed (Von Keyserlingk, 2013). Cabrera et al. (2010) proposed that, considering this level of intensification, TMR systems are a good tool to meet constant returns to scale and dairy farm efficiency.

REPRODUCTION

Reproductive and economic performance is highly influenced by the long-term reproductive strategy on dairy operations, but dairy cows' fertility has declined during the last 30 years (Giordano et al., 2010; Caraviello et al., 2006). Lucy (2001) stated that this reproductive decline is one of the factors responsible for the switch toward larger herds in an attempt to meet the 21st century demands. Higher milk production has been associated with lower reproductive performance but there is no reason to believe that high milk yield and fertility cannot coexist at the same time (Von Keyserlingk et al., 2013). In fact, researchers stated that dairy cows' reproductive performance is not only highly affected by intensive selection for high 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). Walsh et al. (2010) proposed that negative energy balance, postpartum uterine infections, inadequate heat detection and following inseminations, improper ovulation and fertilization, appropriate production and suitable levels of desirable hormones, and pregnancy recognition are the most important factors negatively influencing on dairy cows' reproductive performance. Longer calving to conception

intervals are related to lower BCS (Patton et al., 2007) and shorter calving to conception intervals to higher DMI and positive energy balance during the first 28 d after calving (Oikonomou et al., 2008). During the last decades, subclinical mastitis has been associated with lower fertility (Schrack et al., 2001; Santos et al., 2004; Hertl et al., 2010). Mastitis potentially influences reproductive performance by delaying ovulation (Lavon et al., 2010) and lowering follicular estradiol concentrations (Lavon et al., 2011; Furman et al., 2014). Le Blanc (2010) pointed that there is no clear association yet between higher milk production and lower fertility since traditional reproductive performance measurements (e.g., calving interval, conception rate, etc.) could be considered as incomplete or biased conclusions.

Dairy reproductive programs indirectly impact feed and labor costs because of lactation and dry period length (Giordano et al., 2011). Dairy farmers usually inseminate all eligible cows for breeding without taking into consideration semen and labor associated cost that this practice implies (Shahinfar et al., 2015). Conception rate has a major influence on the percentage of dairy cows pregnant and their average milk production, number of heifers needed either to maintain or modify herd size, labor, and veterinary cost. All these and other factors have a significant impact on dairy farm profitability (Meadows et al., 2005; Giordano et al., 2011).

Individual cows' lactation cycle is sustained by the beginning and renewal of pregnancy (Lucy, 2001). It is widely known that dairies' profitability is highly affected by its reproductive efficiency and that about 70% of cows fail to minimize insemination intervals and so to

maximize fertility (Giordano et al., 2011, 2013). In response to sort the low reproductive efficiency, many different synchronization protocols based on hormone usage have been developed (Carvalho et al., 2015). Although there is not room to question whether the inclusion of new technologies can potentially improve dairy production or efficiency, the acceptance of these new technologies by consumers is debatable (Von Keyserlingk et al., 2013). It is believed that only a small percentage of consumers are totally aware that the U.S. dairy industry strongly relies on the use of hormones to improve low fertility challenges (Moore and Thacker, 2006) and the rest of the consumers, once aware, are very likely to consider hormone usage as an uncertain practice related to milk safety (Vanhonacker et al., 2010; Boogaard et al., 2011). Although timed artificial insemination has been proven to be efficient, dairy producers are aware of consumers' opinions about the use of hormones that this type of programs implies (Neves et al., 2012).

The dairy industry eventually will have to face the fact that reproductive management would be driven by socio-economic constraints (Gengler et al., 2016), and that sustainability it is also linked to ethical and social aspects (Olesen et al., 1999).

YOUNG STOCK

Colostrum, the first secretion of cows after calving, provides immune protection and the first nutrients for the calves, and it is also a source of growth factors and hormones believed to be important for normal calf development. Hence, good quality colostrum not only will allow the correct development of the immune system but also of the digestive tract of calves (Davis and

Drackley, 1998). Passive transfer of Ig can be reduced when calves are fed with inadequate amount and quality of colostrum (Kehoe et al., 2007). On the other hand, feeding high quality colostrum will reduce calf mortality by improving immunity (Quigley and Drewry, 1998). Researchers have different opinions about the amount of colostrum that newborn calves should be receiving according to colostrum quality (e.g., 2.84 to 3.78 L), but it is not questionable that calves should receive as much as possible (Davis and Drackley, 1998). To prevent trans-epithelial migration of pathogenic microbes, colostrum should be offered as fast as possible (Stott et al., 1979). Dairy operations are feeding colostrum to newborn calves in an average of 3.6 h, with large operations more likely to offer a larger quantity and sooner (e.g., average of 2.1 h) than medium or small operations (USDA, 2014).

Dairy calves are typically underfed when compared to how much they would be drinking when fed ad libitum (Vieira et al., 2008). Dairy calves typically have 8 to 12 meals (Reinhardt and Reinhardt, 1981) and drink about 12 L/d of milk when they are fed ad libitum by their dam (de Passille et al., 2008; de Passille and Rushen, 2012). When calves have ad libitum access to liquid diets, they commonly consume 16% to 24% of their body weight compared to typical feeding rates of 8% to 10% (Mylrea, 1966; Khouri and Pickering, 1968; Lineweaver and Hafez, 1969; Marshall and Smith, 1970; Woodford et al., 1987). Large dairy operations were more likely to feed milk replacer three times a day than small or medium operations. Also, a higher

percentage of dairies offered around 1.89 L and a smaller percentage was feeding their calves with a 3.78 L per meal (USDA, 2014).

Cost associated with raising replacement heifers can be decreased by feeding them with high energy diets (Radcliff et al., 2000; Raeth-Knight et al., 2009). Higher milk yield is expected when higher levels of energy and protein are fed to pre-weaned calves (Davis et al., 2011). Although dairy calves are more likely to suffer weaning stress and growth depression during the liquid to solid transition, dairy farmers wean calves as early as possible in an attempt to reduce costs, since solid food is cheaper than milk (Eckert et al., 2015).

MILK QUALITY

Milk synthesis occurs in cells lining the alveoli, and it is influenced by nutritional, hormonal, and mechanical factors (Blowey and Edmondson, 2010). Milk composition changes are directly related to cows' wellbeing and behavior, which are also associated to management and production systems (Dechow et al., 2011).

The term mastitis derives from the Greek words *masto-*: “breast” and *-itis*: “inflammation”. Mastitis is considered as the most common and devastating disease affecting dairy cattle (De Vliegher et al., 2012; Seegers et al., 2003; Lescourret and Coulon, 1994). Higher culling and replacement rates, deaths, extra labor, lower milk yields, and losing payment premiums because of the higher somatic cell counts (SCC) are some of the indirect costs

associated with mastitis on dairy farms. Direct costs include veterinary assistance and drugs, and milk discarded because of the effects of mastitis on milk components (Table 3). Mastitis can have either short-term effects on milk yield and composition of the current lactation or long-term effects that go over the following lactations (Seegers et al., 2003). Another long-term effect, as was stated earlier, is the lower reproduction performance of cows with mastitis. Somatic cell counts are extensively used as mammary health's predictor (Barkema et al., 1999; Harmon, 1994). Somatic cell counts generally are lower than 100,000 cells/mL in healthy mammary quarters. However, clinical mastitis' definition does not require any reference about SCC; when a quarter is affected its SCC will be greater than 200,000 cells/mL (Smith et al., 2001).

Consumers' concerns about antimicrobials and hormones usage have led to higher numbers of organic dairies (Barkema et al., 2015). Therefore, dairy producers need to better understand and improve their mastitis programs; otherwise their dairies will not keep being profitable (Rodrigues and Ruegg, 2005).

THE ROLE OF EXTENSION PROGRAMS IN DAIRY INDUSTRY

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; Mirando et al., 2015). It has been estimated that approximately 30% of producers spend a considerable time of their week searching for information related to their specific commodity (Mirando et al., 2015). Hence, the goal of dairy extension programs is to provide written

materials (e.g., newsletters, web pages, etc.) and organize local meetings or workshops that satisfy dairy producers demand for research-based information (Russel and Bewley, 2011).

Dairy extension programs are constantly adapting their techniques to meet the objectives of educating in the production sector. In the early 1990s, dairy advisory teams were developed in the University of Minnesota. These teams addressed areas where the farms were strong, where there were weaknesses, the opportunities for improvement, and threats to the farms with the objective of delivering targeted recommendations that would allow dairy farmers to meet their goals (Chase et al., 2006). One of the reasons why dairy extension programs must constantly be adapted is because the US dairy industry is not ready to adapt itself to social and environmental landscapes changes (Russel and Bewley, 2011; Von Keyserlingk et al., 2013). An example of this continuous adaptation was the development of training programs for Latino workers (Chase et al., 2006) that surged as a response to the increment in size of US herds (Erskine et al., 2015).

As it was stated before, extension programs have a major role inn educating producers. Furthermore, the USDA National Institute of Food and Agriculture increased its number of grant funding opportunities for extension to encompass important agricultural issues (Mirando et al., 2015).

SUMMARY AND THESIS OBJECTIVES

While dairy herd sizes and total number of cows keep growing as a response to the actual food consumption and consumers concerns, efficient tools that allow farms to be profitable and sustainable are needed. Under this scenario, it is necessary to find strategies that allow researchers to generate new knowledge and how to better apply the existing knowledge. Therefore, the objective of this study was to identify the main characteristics of IL dairy farms and to study potential geographical differences between the North and South regions in IL. Both objectives could help IL dairy farmers improve their operations by improved performance.

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TABLES AND FIGURES

Table 1.1. Changes in the U.S. dairy industry from 1992 to 2006. Adapted from USDA (2008)

Year	Cows ¹	Replacement heifers ²	Operations ³	Milk Production ⁴	Milk Prices ⁵
1992	9,728.2	4,131.4	170,500	7062.43	13.1
1993	9,658.1	4,176.2	157,150	7131.37	12.8
1994	9,507.0	4,124.5	148,140	7338.66	13.0
1995	9,481.8	4,121.3	139,670	7441.18	12.7
1996	9,419.9	4,090.3	130,980	7453.88	14.9
1997	9,317.9	4,058.4	123,700	7652.55	13.3
1998	9,199.0	3,985.7	117,145	7794.98	15.5
1999	9,128.0	4,068.8	110,855	8057.15	14.4
2000	9,182.8	3,999.8	105,055	8254.01	12.3
2001	9,171.7	4,057.0	97,460	8238.14	15.0
2002	9,105.6	4,054.8	91,240	8440.44	12.1
2003	9,141.7	4,113.9	86,360	8509.39	12.5
2004	8,989.5	4,020.0	81,520	8603.28	16.1
2005	9,005.0	4,118.3	78,300	8874.53	15.1
2006	9,062.9	4,275.0	75,140	9049.61	12.9

¹ Total number of U.S. cows = number of milk cows and heifers that have calved x 1,000

² Total number of U.S. replacement heifers = number of replacement heifers x 1,000

³ Total number of U.S. operations

⁴ Average milk production per cow (kg/year)

⁵ Annual milk prices (U.S. dollars) paid to producers per 45.4 kg of milk (cwt)

Table 1.2. Changes in the U.S. dairy industry. Adapted from USDA (2002, 2007, and 2014)

	USDA 2002	USDA 2007	USDA 2014
Nutrition			
Feeding TMR ¹	47	51.1	55.5
Test forage to balance feed rations ¹	71.2	75.5	73.8
Fed lactating cows alfalfa hay/haylage ¹	93.8	92.3	92
Fed lactating cows CS ¹	81.6	87.6	89.4
Rely on pasture during the growing season ¹	47.6	58.9	47.8
Management			
Use handwritten records ¹	74.3	73.5	50.9
Use on-farm computer record system ¹	19.4	19.4	76.7
Use tie stall or stanchion as primary housing for lactating cows ¹	52.5	62.6	38.9
Health			
Percentage of cows with lameness	11.6	14.0	-
Percentage of cows with clinical mastitis	14.7	16.5	24.1
Percentage of cows with retained placenta (more than 24 hs)	7.8	7.8	-
Respiratory Problems	2.7	3.3	-
Milk fever	5.2	4.9	-
Displaced abomasum	3.5	3.5	-
Young Stock			
Average number of hours calves get their first feeding colostrum	-	3.3	3.6
Estimate Ig levels of colostrum ¹	5.2	13.0	53.3
Hand fed > 3.78 L of colostrum during the first 24 hs ¹	31.4	30.9	90.8
Average age of heifers at weaning (weeks)	8.0	8.2	9.0
Reproduction			
Operation average age (months) at first calving	25.4	25.2	25.0
Operation calving interval (months)	13.3	13.2	13.1
Operation average days dry	60.6	57.8	57.1
House no bulls for breeding purpose ¹	45.1	48.3	48.5

Table 1.2 (cont.)**Milk Quality**

Milk cows in tie stall ¹	61.9	60.3	52.6
Milk cows parlor ¹	37.1	39.5	45.8
Percentage of cows being milked in tie stall	28.9	21.8	13.2
Percentage of cows being milked in parlor	70.0	78.2	86.6
Use sand bedding for lactating cows ¹	35	21.9	26
Use sand bedding for dry cows ¹	-	14.4	17.3
Use bST during the current lactation ¹	15.2	15.2	9.7
Average bulk tank SCC	291,000	258,000	200,000
SCC of bulk tank ¹	16.6	20.3	14.1
Bulk tank culture ¹	10.6	13.0	7.6
Bulk SCC < 100,000 ²	2.4	2.8	-
Bulk SCC 100,000 to 199,000 ²	23.6	27.8	-
Bulk SCC 200,000 to 299,000 ²	34.5	40.3	-
Bulk SCC 300,000 to 399,000 ²	21.7	18.7	-
Bulk SCC > 399,000 ²	17.8	10.4	-

¹Percentage of operations²Percentage of operations that brought cattle on the operation during the last year (e.g., 2001, 2013)

Table 1.3. Changes in milk components because of the effects of mastitis.
Adapted from Philpot and Nickerson (1991)

Components	Effect of subclinical mastitis
Total proteins	Decreased slightly
Casein	Decreased
Lactose	Decreased
Solids not fat	Decreased
Butterfat	Decreased
Calcium	Decreased
Phosphorus	Decreased
Potassium	Decreased
Stability and quality	Decreased
Taste	Deteriorate and becomes bitter
Yogurt starter cultures	Inhibited
Plasmin	Increased
Lipase	Increased. Responsible for the “rancid” flavor
Immunoglobulins	Increased
Sodium	Increased (slightly “salty” flavor)

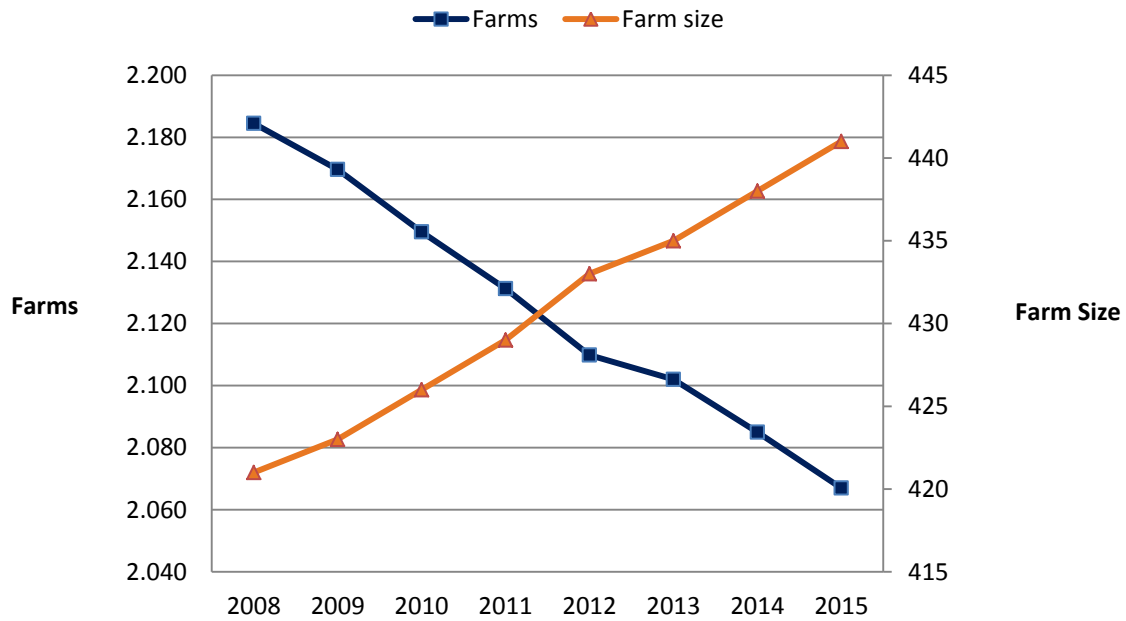


Figure 1.1. Total number of farms (×1,000,000) and average farm size in the U.S. from 2008 to 2015. Adapted from USDA, National Agricultural Statistics Service (2016).

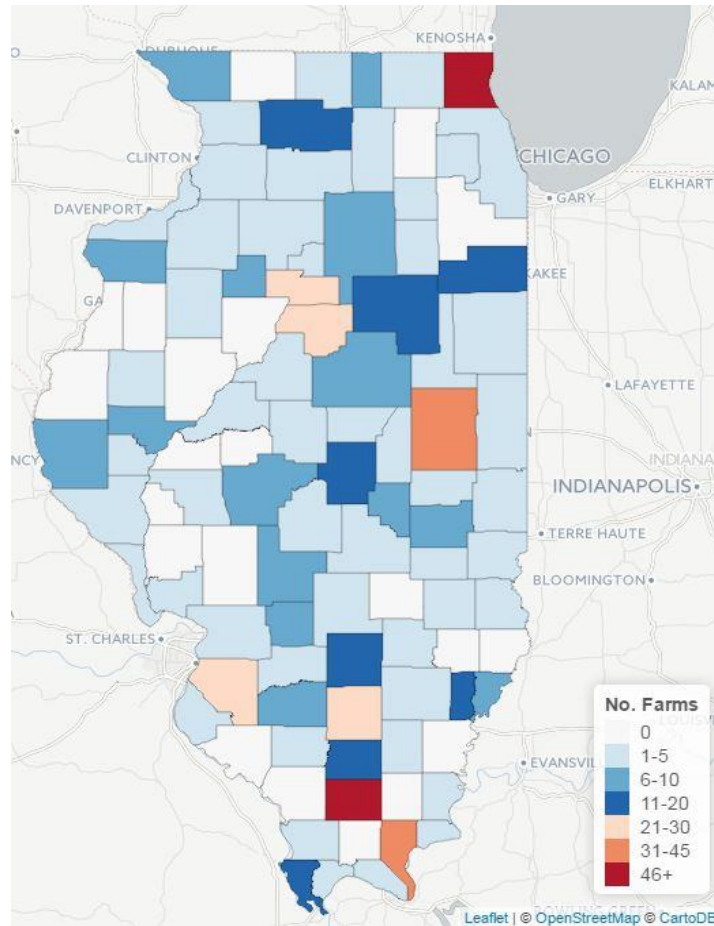


Figure 1.2. Grade “A” dairy farms based on location in Illinois. Adapted from Illinois Department of Public Health, Division of Food, Drugs and Dairies.

Number of Counties in IL with zero farms Grade “A”: $n = 21$

Number of Counties in IL with 1 to 5 farms Grade “A”: $n = 50$

Number of Counties in IL with 6 to 10 farms Grade “A”: $n = 15$

Number of Counties in IL with 11 to 20 farms Grade “A”: $n = 8$

Number of Counties in IL with 21 to 30 farms Grade “A”: $n = 4$

Number of Counties in IL with 31 to 45 farms Grade “A”: $n = 2$

Number of Counties in IL with > 45 farms Grade “A”: $n = 2$

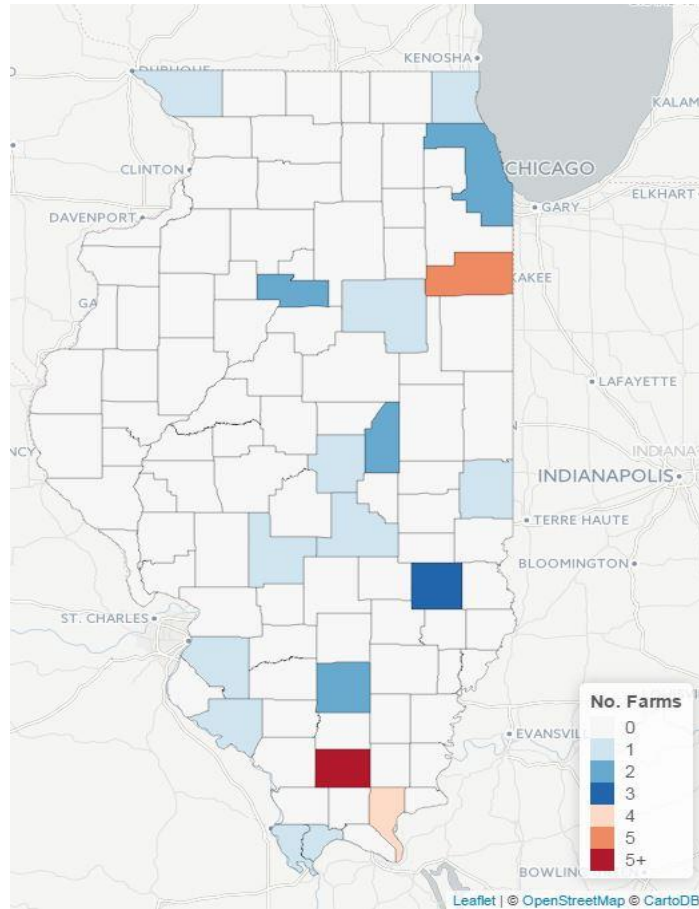


Figure 1.3. Manufacturing dairy farms based on location in Illinois. Adapted from Illinois Department of Public Health, Division of Food, Drugs and Dairies.

Number of Counties in IL with zero Manufactured farms $n = 83$

Number of Counties in IL with 1 Manufactured farms $n = 11$

Number of Counties in IL with 2 Manufactured farms $n = 4$

Number of Counties in IL with 3 Manufactured farms $n = 1$

Number of Counties in IL with 4 Manufactured farms $n = 1$

Number of Counties in IL with 5 Manufactured farms $n = 1$

Number of Counties in IL with 15 Manufactured farms $n = 1$

CHAPTER II. NUTRITION, REPRODUCTION, AND YOUNG STOCK PERFORMANCE IN DAIRY FARMS THROUGHOUT ILLINOIS: A DAIRY FOCUS

TEAM APPROACH

INTRODUCTION

The emergence of new technologies and consumer concerns about food quality are changing the dairy industry. The U.S. dairy industry has experienced a 17% decrease of the total number of cows and a 74% decrease of the number of dairy operations; whereas average milk production per cow increased 59 % during the past 30 yr (Chase et al., 2006). The number of dairy operations is decreasing gradually but the remaining farms tend to be more productive. One of the reasons that these farms are more productive is because of their investment in new technologies and their implementation of targeted management programs (Brotzman et al., 2015). Implementation of new technological and management practices is not always economically feasible (Von Keyserlingk et al., 2013). In concordance with this, 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 operations and to a 40% increase in the average herd size in the last 30 yr (USDA, 2007).

It is expected that by 2020 the total number of dairy farms in the US will be approximately 16,000 (Chase et al., 2006). The implementation of precise technologies and

effective management practices are helping producers to improve efficiency and increase profitability (Brotzman et al., 2015). Knowing the farm's potential causes of inefficiency and efficiency is pivotal to improve its performance (Solís et al., 2009). Improvements in efficiency are highly necessary to the dairy farms to succeed (Tauer, 2001; Alvarez et al., 2008). 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 farms size (Cabrera et al., 2010).

Feed costs, efficiency, and productivity can be increased when cows are fed according to their energy requirements (Zwald and Shaver, 2012). According to USDA (2007), a high number of small and medium farms offer only one ration to their lactating cows while large farms frequently feed different diets based on lactation stage or production. Offering TMR implies better ruminal bacteria fermentation and digestibility; which could also improve feed intake and increase milk production (Soriano et al., 2001). Offering TMR to cows is positively associated with higher levels of technical efficiency (Cabrera et al., 2010).

One of the biggest improvements in management during the last decades has been the change from hand-written reports to on-farm computer records (USDA, 2007). It has been hypothesized that better record-keeping is one of the reasons why people associate lower reproductive performance to greater milk production (Giordano et al., 2011). A better understanding of reproductive performance measurements is needed because the most popular

reproductive performance measurements are considered incomplete or biased (Leblanc, 2010). Although reproductive hormones may be used in lactating cows, consumers are becoming more concerned about their use (von Keyserlingk et al., 2013). If use of future reproductive hormones is prohibited, producers will either have to detect estrus visually or move to automated technologies (Barkema et al., 2015).

Dairy farmers usually offer mil or milk replacer to calves at approximately half of their ad libitum intake (Vieira et al., 2008). Heifers fed milk replacer had inferior average daily gain, and a tendency for lower future milk production, compared to those allowed to suckle three times daily during their first 42 d (Bar-Peled et al., 1997). Approximately 60% of U.S. dairy farms feed milk replacer to their calves, with Western producers less likely to offer milk replacer (Heinrichs et al., 1995). Calves fed ad libitum tend to have between 8 and 12 meals (Reinhardt and Reinhardt, 1981), drinking up to 12 L of milk/d (De Passille and Rushen, 2012). Conventional feeding practices do not consider the energy levels required for successful calf growth and development (Van Amburgh et al., 2005). During cold weather calves' maintenance requirements increase, making it an increase in the amount of milk offered each meal or addition of an extra meal necessary (Drackley, 2008).

Illinois data are in agreement with those described by USDA (2007); therefore, it is necessary to develop new strategies that allow both small and large operations to improve their efficiency. Dairy producers need to better know how their own farms are performing and what

the potential causes of inefficiency exist. Overall, researchers' or government agencies' perspectives and goals are not necessarily the same as farmers may have; 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 IL dairy farms and (2) to study potential geographical differences between the northern and southern regions in IL. Both objectives could help IL dairy farmers 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 allows undergraduate and graduate 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 is made up of a CEO, a president, dairy mentors (e.g., faculty and industry members), and five graduate students that serve as chairmen. Each chairman, helped by one or two graduate and undergraduate students, is in charge of one of the following sections: nutrition, management, milk quality, reproduction, and young stock.

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).

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 assured confidentiality.

Farm selection and data collection

For this study, a total of 20 dairy farms were selected based on their previous approval and willingness to participate in the study. Fourteen of the farms were located in southern (S), and six located in northern (N) IL. During the visits a questionnaire was completed; corn silage (CS), total mixed ration (TMR), and manure were sampled; and temperature (T), relative humidity (RH) and wind speed (WS) measurements were made. Also, DHI records along with an individual farm dataset was 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 dataset. Means and associated standard deviations for milk yield and composition from the last test day (e.g., closest to the visit) and yearly values are shown in Table 2.1.

Questionnaire

The same individual filled in the questionnaire in a one-on-one interview with the producer (owner). The questionnaire had six sections: goals, management, dairy herd characteristics, nutrition, reproduction, and young stock. Nutrition, reproduction, and young stock sections were analyzed in this study (Table 2.2).

Nutrition

Two 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, 1995) and then ground to pass through a 1-mm screen (Wiley mill, Arthur H. Thomas Co., Philadelphia, PA). 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, Watertown, WI,
http://www.rockriverlab.com/Section/Feed/Analysis_Guidelines/index.html).

Corn silage density (**CSD**) was measured on those farms that had either corn silage piles or bags (n = 4 in N; n = 11 in S). Density measurements were performed with a forage probe (Dairy One, Ithaca, NY) attached to a drill. Density samples were obtained from five different areas of each pile or silo bag (upper left, upper right, center, lower left, and lower right). Samples were weighed and dried in order to obtain DM and then density was calculated as recommended by the manufacturer (Dairy One, Ithaca, NY; <http://dairystone.com/analytical-services/feed-and-forage/master-forage-probe/>).

Manure samples were collected for at least five lactating (**LACT**) and five dry (**DRY**) cows on the different pens in each farm and then composited by pen for measurement of apparent total-tract starch digestibility (Lopes et al. 2009 and Schalla et al. 2012) at a commercial laboratory (Rock River Lab, Watertown, WI).

Reproduction

Yearly pregnancy rate (**PR**), first service conception rate (**FSC**), and services per conception rate (**SC**) were obtained from the individual PCDART dataset from 11 farms and subsequently exported to Excel[®] (Microsoft Corp., Redmond, WA). Pregnancy rate was calculated as follows: $PR = [\text{heat detection rate (\% of heat detected)} \times \text{conception rate (\%}]$

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 rate was 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

Data on T, RH, and WS were measured in at least 2 different randomly selected points either in calves' hutches or calves' barns in all farms. A final data set was built in an Excel[®] file with the average of calves' hutches measurements and the average of calves' barns measurements. Ambient temperature, RH, and WS were recorded using a hygro-thermo-anemometer- light meter (Extech 45170, Extech Instruments, Nashua, NH). Temperature humidity index (**THI**) was calculated as follows: $THI = 0.8 \times \text{air temperature} + [\text{relative humidity} \times (\text{air temperature} - 14.4)] + 46.4$ (McDowell et al., 1979).

Statistical Analyses

Statistical analysis was performed using SAS (v9.4 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 (T, 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 (N or S), 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 (T, 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 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 ($n = 1$). In order 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 cm and 0.4 cm sieve data in Table 2.5 are presented back-transformed. Statistical significance was declared as P value < 0.05 , and tendency declared as $P < 0.10$ and > 0.05 .

RESULTS

Nutrition

The questionnaire description is detailed in Table 2.2. Results for the nutrition section of the questionnaire are in Table 2.3. There were no differences between N and S for questions related to herd nutrition. Producers in S had lower odds (OR = 0.17, $P = 0.03$) of feeding ≤ 2 different rations to the herd than feeding > 2 rations to the herd. Also, S had lower odds (OR = 0.18, $P = 0.03$) for CS not being kernel processed than CS being kernel processed.

Analyses of CS are in Table 2.4. The phosphorus concentrations were 0.21 ± 0.009 and 0.17 ± 0.006 % on a DM basis for N and S, respectively ($P = 0.003$). Corn silage density was 168.5 ± 12.2 and 221.2 ± 8.2 kg/m³ for N and S, respectively ($P = 0.003$).

Results of TMR analyses are in Table 2.5. Although DM content did not differ with lactation stage (LACT or DRY), there was a region by stage interaction ($P = 0.006$), and effect of region ($P = 0.02$). The CP was higher ($P = 0.0004$) 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 higher ($P < 0.0001$) for TMR offered to DRY than TMR offered to LACT in both regions (Table 2.5). Starch concentration was higher ($P < 0.0001$) in TMR offered to LACT (25.4 ± 0.8 %) than those offered to DRY (12.8 ± 1.9 %); there was also a tendency ($P = 0.07$) for a region by stage interaction. Calcium concentration was higher ($P < 0.03$) in TMR offered to

LACT (0.78 ± 0.04 %) than those offered to DRY (0.58 ± 0.08 %). Magnesium concentration in the TMR offered to both LACT and DRY was higher ($P = 0.007$) for N (0.34 ± 0.02 %) than S (0.26 ± 0.01 %). Apparent total-tract starch digestibility was 96.0 ± 0.9 and 98.7 ± 2.1 % for LACT and DRY, respectively, in N; and 96.8 ± 0.6 and 97.26 ± 1.2 % for LACT and DRY, respectively in S ($P = 0.89$). The DM of manure was higher for S (15 ± 0.4 %) than N (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 N; and 2.6 ± 0.5 and 2.23 ± 0.99 % for LACT and DRY, respectively in S ($P = 0.87$).

Reproduction

Analyses of the reproduction section of the questionnaire are in Table 2.6. The N had higher odds (OR = 12.0, $P = 0.04$) of knowing the percentage of dystocia of the herd than for not knowing the percentage of dystocia of the herd. There were lower odds (OR = 0.17, $P = 0.03$) for having a voluntary waiting period > 60 d than a voluntary waiting period ≤ 60 d in S. The S had lower 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 N than S (19.8 ± 2.2 vs. 12.6 ± 1.6 , $P = 0.02$). Services per conception was different for cows and heifers (2.63 ± 0.11 vs. 1.76 ± 0.12 , $P < 0.0001$), and also for N and S (2.50 ± 0.13 vs. 1.88 ± 0.10 , $P = 0.001$).

Young Stock

Analyses of the young stock section are in Table 2.7. The N had higher odds (OR = 12.0, $P = 0.04$) than S for having the highest percentage of calf deaths beyond first week after birth than before the first week after birth; S showed lower odds (OR = 0.17, $P = 0.03$) for having the highest percentage of calf deaths beyond the first week after birth. The N had lower odds (OR = 0.09, $P = 0.05$) than S for milk being mixed at a temperature $\leq 40^{\circ}\text{C}$ than a temperature $< 40^{\circ}\text{C}$. The S had higher 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 higher odds (OR = 12.94, $P = 0.03$) of offering milk to calves $\leq 2\text{ x d}$ than offering milk to calves $> 2\text{ x d}$ in S. There were higher odds (OR = 5.99, $P = 0.03$) for offering starter to calves before the first wk after birth than offering it beyond the first week after birth in S. Ambient T were 27.5 ± 2.0 and $27.5 \pm 1.0^{\circ}\text{C}$ for young stock housed in N and S, respectively ($P = 0.97$). The RH was higher for S than N (62.6 ± 2.0 vs. $41.1 \pm 4.0\%$; $P < 0.0001$).

DISCUSSION

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

Corn silage density was higher for S than N; however, no differences between N and S were found for CS particle size. Studies on bunker silo packing (Muck and Holmes, 2006) showed that larger particle size might imply lower density. Density tends to decrease as particle size increases at 4.1 kg of DM/m³ per millimeter of increased length (Muck and Holmes, 2006). A potential explanation for CSD differences between N and S could be variation in bagging machines and operators (Muck and Holmes, 2006). A higher CSD is always preferable since it prevents air infiltration and further storage losses that could happen because of the CS oxidation. Also, a higher CSD because reduces 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, yet S IL had higher odds for processing CS.

It is widely known that offering specific rations for different stages of lactation has the potential to increase efficiency and productivity, and 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 S had higher odds for feeding more than two different rations to the herd; meaning that their income over feed costs could be greater than those farms that are not feeding more than two different rations to the herd (Cabrera et al., 2012).

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 sorting to the detriment of their health. It can potentially increase the risk of subacute ruminal acidosis for dominant cows (Hosseinkhani et al., 2008).

Greater milk production (rolling herd average) has been associated with lower reproductive performance. According to Giordano et al. (2011), lower apparent reproductive performance could be because of management improvements, like better reports. Leblanc (2010) reported that the most popular reproductive performance measurements were either incomplete or biased. In our study, there was no a mathematical but not statistical difference between N and S, where cows in N were producing more milk per day than cows in S. Also, PR was 7.18 points higher for N than S, and SC was 0.61 higher in N. Furthermore, S showed a tendency for lower odds for using hormones on their breeding programs. These data are in concordance with those of Leblanc (2010).

Not surprisingly, S had lower odds of having a greater percentage of calves dying after their first week of life. The S had higher odds for offering ≤ 3.78 L of milk/d to calves. In addition, calves in S were less likely to be fed $> 2x/d$. Calves were more likely to receive starter in their first week of life in S than in N. Total amount of feed offered to calves should be

adjusted according to weather conditions, calf health status, and body weight. Calves are forced to use energy reserves to maintain body temperature when they are not getting more milk in either higher or lower temperatures (Scibilia et al., 1987). According to Scibilia et al. (1987), 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.

CONCLUSION

There were nutritional, reproductive, and young stock management differences between N and S. Farms in S were better ensiling corn; their silos had higher CSD implying lower losses (e.g. CS oxidation) and costs (e.g., more DM stored with a given volume) than farms in N. The tendency of S being less likely to use hormones on their breeding programs could explain why N had a higher PR than S. Farms in N had better feeding management strategies for calves than farms in S. 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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TABLES AND FIGURES

Table 2.1. Means and associated standard deviations for milk production analysis done in the last test closest to the visit, and yearly values in northern (n = 5) and southern farms (n = 12) in Illinois

Variable	Region											
	North ¹				South ²				Overall ³			
	Mean	Median	SD ⁴	Range	Mean	Median	SD ⁴	Range	Mean	Median	SD ⁴	Range
Number of lactating cows ⁵	413	451	192	139 – 669	451	148	949	60 – 3444	439	191	793	60 – 3444
DIM ⁵	187	191	17	160 – 209	203	194	22	174 – 246	198	194	21	160 – 246
Milk yield ⁵ , kg/d	37.9	41.6	6.7	26.1 – 41.9	33.8	32.91	5.7	23.4 – 43.5	35.0	35.2	6.15	23.4 – 43.5
Tank protein concentration ⁵ , %	3.18	3.00	0.35	3.00 – 3.80	3.08	3.05	0.21	2.80 – 3.50	3.11	3.0	0.25	2.8 – 3.8
Tank fat concentration ⁵ , %	3.88	3.60	0.75	3.40 – 5.20	3.56	3.40	0.43	3.10 – 4.30	3.65	3.5	0.54	3.10 – 5.20
Somatic cell count/ml ⁶	196	189	21	172 – 219	207	182	109.3	102 – 526	204.0	183	91.4	102 – 526
Somatic cell count score ⁷	2.64	2.60	0.25	2.3 – 3.0	2.50	2.45	0.49	1.80 – 3.50	2.54	2.50	0.43	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	33.9	33.7	5.74	21.5 – 41.0
Tank yearly protein concentration, %	3.94	3.1	0.62	3.00 – 3.80	3.73	3.1	0.51	2.90 – 4.70	3.79	3.1	0.54	2.90 – 5.00
Tank yearly fat concentration, %	3.24	3.80	0.32	3.40 – 5.00	3.17	3.7	0.19	3.00 – 3.70	3.19	3.7	0.23	3.00 – 3.80
Yearly somatic cell count ⁶	193	208	37	136 – 231	236	219	79	113 – 409	223	214	71	113 – 409
Yearly somatic cell count score ⁷	2.64	2.60	0.32	2.20 – 3.10	2.66	2.65	0.43	1.90 – 3.50	2.65	2.60	0.39	1.90 – 3.50

¹ Cows in North region: n = 1396.

² Cows in South region: n = 5409.

³ Overall: cows in northern and southern Illinois (n = 6805).

⁴ SD: standard deviation.

⁵ Last test date related to the team's visit.

⁶ Somatic cell count = SCC × 1,000.

⁷ Somatic cell count score = linear SCS.

Table 2.2. Questionnaire's description

Question	Answer	
Nutrition		
Does your farm measure dry matter intake for cows?	Yes	No
How many rations does your farm currently use?	Equal or less than two rations	More than two rations
Do you push up feed?	Yes	No
How long does it take to feed?	Equal or less than two h	More than two h
Do you weigh back refusals?	Yes	No
What is your farm target refusal?	Equal or less than 2 %	More than 2 %
Do you shake out TMR in the Penn state box?	Yes	No
Do you know how many hybrids were used on the corn?	Equal or less than 2	More than 2
Was the corn kernel processed?	Yes	No
Reproduction		
Do you know what % of dystocia your farm has?	Yes	No
Do you know what % of abortion your farm has?	Yes	No
Do you know what % of dead on arrival your farm has?	Yes	No
What is your average days open?	Equal or less than 150	More than 150
Do you know what your actual calving interval is?	Yes	No
Does your farm breeding program use any type of hormone at some point?	Yes	No
What is your farm voluntary waiting period?	Equal or less than 60 d	More than 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 % of calf deaths?	Before the first wk of age	After the first wk of age
How much colostrum does each calf get in total?	Equal or less than 3.78 L	More than 3.78 L
How much milk is fed per day?	Equal or less than 3.78 L	More than 3.78 L
How many times is milk fed?	Twice/d	More than twice/d
At what temperature is milk mixed?	From 37 ⁰ C to 40 ⁰ C	From 41 ⁰ C to 44 ⁰ C
How long does it take to get the milk to the calf?	Equal or less than 15 min	More than 15 min
Do you adjust amount fed depending on time of the year?	Yes	No
When starter is first offered?	Before 1 wk	More than 1 wk
Is starter intake estimated?	Yes	No
How often is water changed?	Less than 2/d	Equal or more than 2/d
At what age are calves weaned?	Equal or before 6 wk	After 6 wk
Do you have a vaccination protocol?	Yes	No

Table 2.3. Multivariate logistic mixed model of questions related to the farms' herd nutrition characteristics from northern (N) and southern (S) farms in Illinois

Variable	Region diff. ¹	Level	Coefficient	SE	OR	CL ²	P- value
Overall							
If the farm measures dry matter intake ³	N – S	No	– 0.22	0.26	0.80	0.09 – 7.24	0.83
Numbers of rations currently used ⁴	N – S	≤ 2 rations	0.18	1.33	1.20	0.07 – 19.84	0.89
If the farm push up feed ⁵	N – S	No	– 1.02	0.33	0.36	0.03 – 4.76	0.42
How long it takes to deliver feed ⁶	N – S	> 2 h	0.98	0.25	2.67	0.31 – 22.76	0.34
If the farm weights back refusals ⁷	N – S	No	– 1.61	0.23	0.20	0.02 – 1.81	0.14
Farm's target refusals ⁸	N – S	≤ 2 %	1.89	1.22	6.67	0.51 – 86.74	0.13
If the farm shakes TMR in the Penn State box ⁹	N – S	No	– 0.98	0.42	0.37	0.04 – 3.20	0.35
How many hybrids were used ¹⁰	N – S	> 2	0.12	0.14	1.12	0.12 – 10.40	0.91
Was the corn kernel processed? ¹¹	N – S	No	0.09	0.28	1.10	0.06 – 18.52	0.94
Northern farms							
If the farm measures dry matter intake ³	-	No	0.69	0.87	1.99	0.22 – 18.54	0.46
Numbers of rations currently used ⁴	-	≤ 2 rations	– 1.61	1.09	0.20	0.01 – 3.35	0.20
If the farm push up feed ⁵	-	No	– 1.61	1.09	0.20	0.01 – 3.35	0.20
How long it takes to deliver feed ⁶	-	> 2 h	0.69	0.87	1.99	0.22 – 18.54	0.46
If the farm weights back refusals ⁷	-	No	– 0.69	0.87	0.50	0.05 – 4.62	0.46
Farm's target refusals ⁸	-	≤ 2 %	1.61	1.09	5.00	0.30 – 83.10	0.20
If the farm shakes TMR in the Penn State box ⁹	-	No	– 0.69	0.87	0.50	0.05 – 4.62	0.46
How many hybrids were used ¹⁰	-	> 2	– 0.69	0.87	0.50	0.05 – 4.62	0.46
Was the corn kernel processed? ¹¹	-	No	– 1.61	1.09	0.20	0.01 – 3.35	0.20
Southern farms							
If the farm measures dry matter intake ³	-	No	0.91	0.59	2.48	0.70 – 8.94	0.14
Numbers of rations currently used ⁴	-	≤ 2 rations	– 1.79	0.76	0.17	0.03 – 0.87	0.03
If the farm push up feed ⁵	-	No	– 0.58	0.56	0.56	0.17 – 1.86	0.31
How long it takes to deliver feed ⁶	-	> 2 h	– 0.29	0.54	0.75	0.23 – 2.41	0.60
If the farm weights back refusals ⁷	-	No	0.91	0.59	2.48	0.70 – 8.94	0.14
Farm's target refusals ⁸	-	≤ 2 %	– 0.29	0.54	0.75	0.23 – 2.41	0.60
If the farm shakes TMR in the Penn State box ⁹	-	No	0.29	0.54	1.34	0.41 – 4.26	0.60
How many hybrids were used ¹⁰	-	> 2	– 0.81	0.60	0.44	0.12 – 1.63	0.20
Was the corn kernel processed? ¹¹	-	No	– 1.70	0.77	0.18	0.03 – 0.98	0.04

Table 2.3 (cont.)

¹ Difference of regions least square means.

² Odds Ratio 95% confidence limit.

³ N [n = 6; yes (referent) = 2, and no = 4] and S [n = 14; yes (referent) = 4, and no = 10].

⁴ N [n = 6; > 2 rations (referent) = 5, and ≤ 2 rations = 1] and S [n = 14; > 2 rations (referent) = 2, and ≤ 2 rations = 12].

⁵ N [n = 6; yes (referent) = 5, and no = 1] and S [n = 14; yes (referent) = 9, and no = 5].

⁶ N [n = 6; ≤ 2 h (referent) = 2, and > 2 h = 4] and S [n = 14; ≤ 2 h (referent) = 8, and > 2 h = 6].

⁷ N [n = 6; yes (referent) = 4, and no = 2] and S [n = 14; yes (referent) = 4, and no = 10].

⁸ N [n = 6; > 2 % refusals (referent) = 1, and ≤ 2 % refusals = 5] and S [n = 14; > 2 % refusals (referent) = 8, and ≤ 2 % refusals = 6].

⁹ N [n = 6; yes (referent) = 4, and no = 1] and S [n = 14; yes (referent) = 6, and no = 8].

¹⁰ N [n = 6; > 2 hybrids (referent) = 2, and ≤ 2 hybrids = 4] and S [n = 14; > 2 hybrids (referent) = 4, and ≤ 2 hybrids = 10].

¹¹ N [n = 6; yes (referent) = 5 and no = 1] and S [n = 13; yes (referent) = 11, and no = 2].

Table 2.4. Least squares means and associated standard errors for corn silage analyses¹, and particle size characterization in northern and southern Illinois

Variable	Region		SE	<i>P</i> - value
	North ²	South ³		
Dry matter, %	38.7	37.2	2.0	0.45
Crude protein, % of DM	9.69	9.06	0.32	0.06
Acid detergent fiber, % of DM	21.9	21.4	1.2	0.70
Neutral detergent fiber, % of DM	35.8	35.5	1.9	0.88
Phosphorus, % of DM	0.21	0.17	0.01	0.0035
Potassium %, 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
Calcium, % of DM	0.26	0.20	0.03	0.11
Magnesium, % of DM	0.15	0.11	0.01	0.04
PS ⁴ 1.9 cm	11.8	7.1	2.2	0.08
PS ⁴ 0.78 cm	61.7	60.0	3.8	0.67
PS ⁴ 0.40 cm	16.7	20.9	3.5	0.24
PS ⁴ bottom pan	9.8	12.0	3.5	0.55
Density ⁵ , kg/m ³	168	221	12	0.003

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

² n = 5.

³ n = 12.

⁴ Penn State particle size analyses.

⁵ Density: North (n bag = 2, n pile = 2); South (n bag = 7, n pile = 4).

Table 2.5. Least squares means and associated standard errors for total mixed rations (TMR), and particle size characterization of the TMR in northern farms (n = 5) and southern farms (n = 14) in Illinois; by regions, and by lactation stage

Variable	Region						SE	P - value		
	North			South				Region	Stage ¹	Region × Stage ¹
	Lactating ²	Dry ³	Overall ⁴	Lactating ⁵	Dry ⁶	Overall ⁷				
Dry matter, %	46.2	51.2	48.7	47.3	40.8	44.1	3.2	0.02	0.71	0.006
Crude protein, % of DM	16.5	12.4	14.4	17.2	13.3	15.2	1.6	0.44	0.0004	0.91
Acid detergent fiber ,% of DM	22.8	37.6	30.2	24.4	32.6	28.5	3.0	0.38	< 0.0001	0.09
Neutral detergent fiber, % of DM	33.8	56.5	45.1	38.2	50.9	44.6	3.1	0.78	< 0.0001	0.01
Phosphorus, % of DM	0.41	0.30	0.36	0.38	0.33	0.35	0.04	0.97	0.0007	0.24
Potassium, % 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
Calcium, % of DM	0.86	0.54	0.70	0.70	0.62	0.66	0.08	0.69	0.03	0.20
Magnesium, % 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

¹Stage: lactating and dry samples.

²Lactating samples: n = 11.

³Dry samples: n = 2.

⁴Overall: lactating and dry samples: n = 13.

⁵Lactating samples: n = 28.

⁶Dry samples: n = 6.

⁷Overall: lactating and dry samples: n = 34.

⁸Penn state particle size analysis.

Table 2.6. Multivariate logistic mixed model of questions related to the farms' herd reproduction characteristics from northern (N) and southern (S) farms in Illinois

Variable	Region diff. ¹	Level	Coefficient	SE	OR	CL ²	P- value
Overall							
If the % of dystocia was known ³	N – S	No	2.48	1.15	12.00	1.06 – 135.7	0.04
If the % of abortion was known ⁴	N – S	No	0.40	1.02	1.50	0.18 – 12.80	0.69
If the % of dead on arrival was known ⁵	N – S	No	0.98	1.02	2.67	0.31 – 22.76	0.35
Average of days open ⁶	N – S	> 150	0.56	1.46	1.75	0.07 – 45.66	0.71
If the actual calving interval was known ⁷	N – S	No	– 0.10	1.03	0.90	0.10 – 7.84	0.92
If the farm breeding program uses any type of hormone ⁸	N – S	No	0.61	1.08	1.83	0.19 – 17.86	0.58
Farm voluntary waiting period ⁹	N – S	> 60	0.18	1.33	1.20	0.07 – 19.84	0.89
If the farm uses bulls for clean up ¹⁰	N – S	No	0.98	1.02	2.67	0.31 – 22.76	0.35
If the metabolic problems are identified ¹¹	N – S	No	0.95	1.51	2.60	0.11 – 61.90	0.53
If the farm records calving scores ¹²	N – S	No	0.22	1.05	1.25	0.14 – 11.32	0.84
Northern farms							
If the % of dystocia was known ³	-	No	0.69	0.87	1.99	0.22 – 18.54	0.45
If the % of abortion was known ⁴	-	No	0.69	0.87	1.99	0.22 – 18.54	0.45
If the % of dead on arrival was known ⁵	-	No	0.69	0.87	1.99	0.22 – 18.54	0.45
Average of days open ⁶	-	> 150	– 0.69	1.22	0.5	0.00 – 97.51	0.63
If the actual calving interval was known ⁷	-	No	– 0.69	0.87	0.5	0.05 – 4.62	0.46
If the farm breeding program uses any type of hormone ⁸	-	No	– 0.69	0.87	0.5	0.05 – 4.62	0.46
Farm voluntary waiting period ⁹	-	> 60	– 1.61	1.01	0.20	0.01 – 3.35	0.20
If the farm uses bulls for clean up ¹⁰	-	No	0.69	0.87	1.99	0.22 – 18.54	0.45
If the metabolic problems are identified ¹¹	-	No	– 1.61	1.01	0.20	0.01 – 3.35	0.20
If the farm records calving scores ¹²	-	No	– 0.69	0.87	1.99	0.05 – 4.62	0.46
Southern farms							
If the % of dystocia was known ³	-	No	– 1.79	0.76	0.17	0.03 – 1.15	0.03
If the % of abortion was known ⁴	-	No	0.28	0.54	1.32	0.41 – 4.26	0.60
If the % of dead on arrival was known ⁵	-	No	– 0.28	0.54	0.76	0.23 – 2.41	0.60
Average of days open ⁶	-	> 150	– 1.25	0.80	0.29	0.05 – 1.80	0.16
If the actual calving interval was known ⁷	-	No	– 0.59	0.56	0.55	0.17 – 1.86	0.31
If the farm breeding program uses any type of hormone ⁸	-	No	– 1.29	0.65	0.27	0.07 – 1.12	0.06

Table 2.6 (cont.)

Farm voluntary waiting period ⁹	-	> 60	- 1.79	0.76	0.17	0.03 – 1.15	0.03
If the farm uses bulls for clean up ¹⁰	-	No	- 0.28	0.54	0.76	0.23 – 2.41	0.60
If the metabolic problems are identified ¹¹	-	No	- 2.56	1.04	0.08	0.01 – 1.38	0.03
If the farm records calving scores ¹²	-	No	- 0.92	0.59	0.40	0.11 – 1.43	0.03

¹ Difference of regions least square means.

² Odds Ratio 95% confidence limit.

³ N [n = 6; yes (referent) = 2 and no = 4] and S [n = 14; yes (referent) = 12, and no = 2].

⁴ N [n = 6; yes (referent) = 2 and no = 4] and S [n = 14; yes (referent) = 6, and no = 8].

⁵ N [n = 6; yes (referent) = 2 and no = 4] and S [n = 14; yes (referent) = 8, and no = 6].

⁶ N [n = 3; ≤ 150 (referent) = 2 and > 150 = 1] and S [n = 9; ≤ 150 (referent) = 7 and > 150 = 2].

⁷ N [n = 6; yes (referent) = 4 and no = 2] and S [n = 14; yes (referent) = 9, and no = 5].

⁸ N [n = 6; yes (referent) = 4 and no = 2] and S [n = 14; yes (referent) = 11, and no = 3].

⁹ N [n = 6; ≤ 60 (referent) = 5 and > 60 = 1] and S [n = 14; ≤ 60 (referent) = 12 and > 60 = 2].

¹⁰ N [n = 6; yes (referent) = 2 and no = 4] and S [n = 14; yes (referent) = 8, and no = 6].

¹¹ N [n = 6; yes (referent) = 5 and no = 1] and S [n = 14; yes (referent) = 13, and no = 1].

¹² N [n = 6; yes (referent) = 4 and no = 2] and S [n = 14; yes (referent) = 10, and no = 4].

Table 2.7. Multivariate logistic mixed model of questions related to the farms' young stock characteristics from northern (N) and southern (S) farms in Illinois

Variable	Region diff. ¹	Level	Coefficient	SE	OR	CL ²	P- value
Overall							
When is the largest % of calf deaths ³	N – S	> 1 wk	2.49	1.15	12.00	1.06 – 135.74	0.04
How much colostrum does each calf get? ⁴	N – S	≤ 3.78 L	– 1.32	1.22	0.27	0.02 – 3.47	0.29
How much milk is fed per day ⁵	N – S	≤ 3.78 L	– 0.95	1.51	0.38	0.01 – 9.16	0.53
How many times is milk offered per day ⁶	N – S	≤ twice/d	– 0.95	1.51	0.38	0.01 – 9.16	0.53
Temperature that milk is mixed ⁷	N – S	≤ 40° C	– 2.39	1.16	0.09	0.01 – 1.05	0.05
How long it take to get the milk to the calf ⁸	N – S	> 15 min	– 0.31	1.27	0.73	0.05 – 10.67	0.81
Milk adjustment depending on time of the year ⁹	N – S	No	1.02	1.23	2.78	0.21 – 36.75	0.42
When is starter offered ¹⁰	N – S	≤ 1 wk	– 1.09	1.15	0.33	0.02 – 3.77	0.35
If starter intake is estimated ¹¹	N – S	No	– 0.12	1.05	0.89	0.09 – 8.22	0.91
How often is water change ¹²	N – S	≤ twice/d	0.40	1.28	1.50	0.10 – 22.24	0.75
Age of weaned ¹³	N – S	> 6 wk	1.14	1.23	0.32	0.23 – 42.30	0.37
If the farm has a vaccination protocol ¹⁴	N – S	No	0.22	1.04	0.80	0.14 – 11.32	0.84
Northern farms							
When is the largest % of calf deaths ³	-	> 1 wk	0.69	0.87	1.99	0.22 – 18.54	0.46
How much colostrum does each calf get? ⁴	-	≤ 3.78 L	– 1.61	1.09	0.20	0.01 – 3.35	0.20
How much milk is fed per day ⁵	-	≤ 3.78 L	1.61	1.09	5.00	0.30 – 83.10	0.20
How many times is milk offered per day ⁶	-	≤ twice/d	1.61	1.09	5.00	0.30 – 83.10	0.20
Temperature that milk is mixed ⁷	-	≤ 40° C	– 0.69	0.87	0.50	0.05 – 4.62	0.46
How long it take to get the milk to the calf ⁸	-	> 15 min	– 1.61	1.09	0.20	0.01 – 3.35	0.20
Milk adjustment depending on time of the year ⁹	-	No	1.61	1.09	5.00	0.30 – 83.10	0.20
When is starter offered ¹⁰	-	≤ 1 wk	0.69	0.87	1.99	0.22 – 18.54	0.46
If starter intake is estimated ¹¹	-	No	0.69	0.87	1.99	0.22 – 18.54	0.46
How often is water change ¹²	-	≤ twice/d	1.61	1.09	5.00	0.30 – 83.10	0.20
Age of weaned ¹³	-	> 6 wk	1.61	1.09	5.00	0.30 – 83.10	0.20
If the farm has a vaccination protocol ¹⁴	-	No	– 0.69	0.87	0.50	0.05 – 4.62	0.46
Southern farms							
When is the largest % of calf deaths ³	-	> 1 wk	– 1.79	0.76	0.17	0.03 – 1.15	0.03
How much colostrum does each calf get? ⁴	-	≤ 3.78 L	– 0.29	0.54	0.75	0.23 – 2.41	0.60
How much milk is fed per day ⁵	-	≤ 3.78 L	2.56	1.03	12.94	1.38 – 122.73	0.02
How many times is milk offered per day ⁶	-	≤ twice/d	2.56	1.03	12.94	1.38 – 122.73	0.02

Table 2.7 (cont.)

Temperature that milk is mixed ⁷	-	≤ 40° C	1.70	0.77	5.47	1.03 – 29.37	0.04
How long it take to get the milk to the calf ⁸	-	> 15 min	- 1.29	0.65	0.27	0.01 – 1.12	0.06
Milk adjustment depending on time of the year ⁹	-	No	0.59	0.56	1.80	0.54 – 5.99	0.31
When is starter offered ¹⁰	-	≤ 1 wk	1.79	0.76	5.99	0.03 – 1.15	0.03
If starter intake is estimated ¹¹	-	No	0.82	0.60	2.27	0.61 – 8.33	0.20
How often is water change ¹²	-	≤ twice/d	1.20	0.66	3.32	0.79 – 14.01	0.65
Age of weaned ¹³	-	> 6 wk	0.47	0.57	1.60	0.46 – 5.53	0.42
If the farm has a vaccination protocol ¹⁴	-	No	- 0.92	0.59	0.40	0.11 – 1.43	0.14

¹ Difference of regions least square means.

² Odds Ratio 95% confidence limit.

³ N [n = 6; ≤ 1st wk of life (referent) = 1 and > 1st wk of life = 5] and S [n = 14; ≤ 1st wk of life (referent) = 6 and > 1st wk of life = 8].

⁴ N [n = 6; > 3.78 L (referent) = 2, and ≤ 3.78 L = 4] and S [n = 14; > 3.78 L (referent) = 2, and ≤ 3.78 L = 4].

⁵ N [n = 6; > 3.78 L (referent) = 5, and ≤ 3.78 L = 1] and S [n = 14; > 3.78 L (referent) = 13, and ≤ 3.78 L = 1].

⁶ N [n = 6; > twice/d (referent) = 5, and > twice/d = 1] and S [n = 14; > twice/d (referent) = 13, and ≤ twice/d = 1].

⁷ N [n = 6; > 40° C (referent) = 2, and ≤ 40° C = 4] and S [n = 13; > 40° C (referent) = 11, and ≤ 40° C = 2].

⁸ N [n = 3; ≤ 15 min (referent) = 5 and > 15 min = 1] and S [n = 14; ≤ 15 min (referent) = 11 and > 15 min = 3].

⁹ N [n = 6; yes (referent) = 1 and no = 5] and S [n = 14; yes (referent) = 5, and no = 9].

¹⁰ N [n = 6; > 1 wk of life (referent) = 4, and ≤ 1 wk of life = 2] and S [n = 14; > 1 wk of life (referent) = 12, and ≤ 1 wk of life = 2].

¹¹ N [n = 6; yes (referent) = 2, and no = 4] and S [n = 13; yes (referent) = 4, and no = 9].

¹² N [n = 6; > twice/d (referent) = 1, and > twice/d = 5] and S [n = 13; > twice/d (referent) = 3, and ≤ twice/d = 10].

¹³ N [n = 6; ≤ 6 wk of life (referent) = 1, and > 1 wk of life = 5] and S [n = 13; ≤ 1 wk of life (referent) = 5, and > 6 wk of life = 8].

¹⁴ N [n = 6; yes (referent) = 4 and no = 2] and S [n = 14; yes (referent) = 10, and no = 14].

CHAPTER III. MANAGEMENT PRACTICES AND BEDDING

CHARACTERISTICS ARE ASSOCIATED WITH MILK QUALITY: A DAIRY FOCUS

TEAM APPROACH

INTRODUCTION

Consumers of dairy products have been more concerned about food quality and food security than ever before (Vanhonacker et al., 2010; Ingenbleek and Immink 2011). The biggest concerns are related to the presence of antibiotic residues in milk, transfer of antibiotic resistance from animals to humans, and last but not least, possibility of getting any pathogen by consuming milk or milk products (Schukken et al., 2003). Due to consumers' constraints about hormones and antimicrobials use, the number of organic farms has increased. Conventional farms have an opportunity to implement and better communicate to the consumer management practices associated with milk safety (Barkema et al., 2015). Studies have shown that mastitis treatments in lactating (**LACT**) or dry (**DRY**) cows are associated with approximately 80% of antibiotics residues found in milk (Ruegg, 2000). It has been suggested that ceftiofur (a third-generation cephalosporin) is involved in extended-spectrum β -lactamase resistance (Grove-White and Murray, 2009). According to USDA (2007), ceftiofur is the second most common antibiotic used to treat cows with mastitis. Although it is widely known that dairy farms' profitability vastly relies on milk prices (Barkema et al., 2015), dairy farmers tend to be more effectively encouraged by quality penalties than for quality bonuses (Valeeva et al., 2007).

Dairy farms' management practices such as milking procedures and health disorder detection systems have considerably improved in the last years; however, the proportion of cows affected by mastitis has increased at least 2% from 2002 to 2007 (USDA, 2007). Mastitis, the most prevalent disease in dairy cattle in the U.S., is currently considered as one of the most expensive diseases among dairy farms (Seegers et al., 2003). It not only implies milk production losses, but also veterinarian payment services, expensive drugs are needed for treatments with a consequently milk waste (Lescourret and Coulon, 1994). Somatic cells are considered part of the cow's natural defense mechanism from the immune system (Sordillo and DeRosa, 1997) and regularly used to differentiate infected from uninfected udder quarters (Schukken et al., 2003). Although the regulatory limit in the U.S. is 750,000 cells/mL bulk tank SCC, 89.6% of U.S. dairy farms reported to have less than 400,000 cells/mL bulk tank SCC. If milk does not gather processors' quality milk guidelines, producers can lose quality premiums (USDA, 2007). Hence, better SCC control programs are pivotal to diminish risks of having antibiotic residues in milk and to assure better food security (Ruegg, 2000).

Researchers have linked management practices on bedding quality with SCC (Wenz et al., 2007; Rowbotham and Ruegg, 2015). Bedding management is one of the daily dairy farm practices that deserve to be further investigated. Studies show that cows choose softer lying surfaces (Fulwider and Palmer, 2004) and spend more time lying down in stalls with more bedding (Tucker et al., 2003; Tucker and Weary, 2004). According to Drissler et al. (2005) cows

reduce their time lying down by 10 min/d for every 1 cm of missing sand bedding. Cows would rather spend less time lying down if their bedding surface is not appropriate, generating signs of stress and consequently impact on health and production (Munksgaard et al., 1999). Cows spend on average 12 to 14 h lying down (Reich, et al., 2010), which means that their udders are in direct contact with bedding pathogens for the same amount of time. There is a positive correlation between bedding bacterial counts and bacterial counts on teat ends (Zdanowicz, et al. 2004). Also, a positive association between the highest hygiene udder scores and environmental mastitis was found by Schreiner et al (2003).

Therefore, the objectives of this research were (1) to identify on-farm practices associated with milk quality in dairy farms and (2) to survey potential geographical differences between N and S IL.

MATERIALS AND METHODS

Dairy Focus Team approach

The Dairy Focus Team was established in 2014 as component of an extension program that allows undergraduate and graduate students to further their knowledge by getting hands on experience evaluating dairy farms as well as working with Illinois dairy producers to maximize profitability. The Dairy Focus Team is made up of a CEO, a president, dairy mentors (e.g. faculty and industry members), and five graduate students as chairmen. Each chairman, helped by one or

two graduate and undergraduate students, is in charge of one of the following sections: nutrition, management, milk quality, reproduction, and young stock.

To standardize data collection, a questionnaire was developed. Also, five forms were to make data collection easier and to record specific information from each sector in the dairy farm (e.g., number of stalls on each pen, number of cows drinking on each pen). All students were trained on how to use these forms, and also on how to collect samples, and to record measurements [e.g., wind speed (**WS**), relative humidity (**RH**), temperature (**T**), etc.]. Two trained observers made all lameness, vaginal discharge, and manure scores assessments. The same observers took manure and bedding samples. Other trained personnel recorded LACT and DRY cows' behavior and also pens' measurements (total length, curb to neck rail, neck rail down, and width, T, RH, and WS) on each farm.

Research approval

The University of Illinois Institutional Review Board (IRB # 14636) approved all procedures that were done in this research. Prior to starting the questionnaire and taking samples, all participants read and signed a consent letter where confidentiality was assured.

Farm selection and data collection

A total of twenty dairy farms participated in this study. Six of the farms were located in N and fourteen of the farms were located in S. Farmers previously expressed their willingness and

consent to be part of this study. In addition, DHI records along with an individual farm dataset 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.

Survey questionnaire

The same questionnaire was used in all farms that participated in this study. To standardize data collection, the questionnaire was filled in by the same individual, in a one-on-one interview with the dairy farmer (e.g., owner, manager). The questionnaire had six sections as follow: goals, management, dairy herd characteristic, nutrition, reproduction, and young stock. Goals, management, and dairy herd characteristic sections were analyzed for the purpose of this study (Table 3.1).

Hygiene score

Udder hygiene score (**UHS**), teat hygiene score (**THS**), lower leg score (**LLS**), upper leg score (**ULS**), and hock score (**HS**) were observed in 15 LACT cows randomly selected at the milking parlor in each farm. Cow cleanness scoring (THS, LLS, and ULS) was based on a 4 – point score as follow 1= clean, 2 = some dirt, 3 = dirty, 4 = very dirty with caked-on dirt (Schreiner and Ruegg, 2003). Hock scores were classified as follow: 1 = no swelling, no hair

missing; 2 = no swelling, some bald areas; 3 = swelling or some lesion. Cows were considered not clean if UHS, THS, LLS, ULS, and HS were > 1 .

Lameness score

Lameness scores were assigned to 15 LACT and 15 DRY cows randomly selected in the different pens on each farm. Locomotion scoring was based on a 5 – point scoring after the observation of cows walking and standing, with emphasis on their back posture. According to this criteria, cows were classified as 1 = normal, 2 = slightly irregular/asymmetrical gait, 3 = favoring of one or more limb, 4 = severely lame, 5 = extremely lame (Bicalho et al., 2007). Cows were considered lame if LS was ≥ 2 .

Vaginal discharge

Fifteen LACT and 15 DRY cows were randomly scored in a scale from 0 to 3 for vaginal discharge (**VDS**) on the different pens in each farm. Cows were scored 0 when they presented translucent or clear mucus; scored 1 if there was any evidence of mucus containing flecks of white or off-white pus material; scored 2 when theirs discharge was 50% white or off-white muco-purulent material; and scored 3 if theirs discharge was more than 50%, white, yellow purulent or sanguineous material (Sheldon et al., 2006). Cows were considered as having abnormal discharge when VDS was > 1 .

Manure score and BCS

Manure scores were assigned to 15 LACT and 15 DRY cows randomly selected on the different pens in each farm. Manure was scored as follow: 1 = runny: liquid consistency, splatters on impact, spreads readily; 2 = loose: may pile slightly and spreads and splatters moderately on impact and setting; 3 = soft: firm but not hard, piles but spreads slightly on impact and settling; 4 = dry: hard, dry appearance, original form not distorted on impact and settling. Body condition score was assigned in quarter – unit increments (Ferguson et al., 1994).

Bedding sand samples

A total of 49 sand bedding samples were randomly taken from 4 spots (front left, front right, middle, rear left, and rear right) on different pens located in LACT and DRY cows' stalls on each farm. Dry matter (**DM**) content was analyzed by drying for 24 h in a forced-air oven at 110°C (AOAC, 1995a). Organic matter (**OM**) was analyzed by drying for 12 h in a forced-air oven at 3,315°C. Sieve analysis of dried sand samples was performed using six different U.S. sieve sizes as follow: 16 (1.18mm), 30 (0.6 mm), 50 (0.3mm), 100 (0.15mm), 200 (0.075mm), and a solid pan (U.S. standard stainless steel sieves, Thermo Fisher Scientific, Inc. Waltham, MA). Sieves were stacked from the largest to the smallest mesh opening. This column was placed in a portable sieve shaker (Portable Sieve Shaker. Model RX – 24. W.S. Tyler Incorporated Combustion Engineering Inc., Mentor, OH) for 10 min. This procedure was repeated 3 times for each sample. Sand accumulated in each sieve was weighed and recorded for

calculations of particle size distribution and mean particle size (**PS**), particle per gram (**PG**), particle size distribution (**PSD**), and surface area (**SA**) as described in ASAE (2008).

Behavior observations

The same individual observed cows' behavior at each LACT and DRY pen. Observation was performed before collection of any other samples in order to avoid an interference with regular cow's behavior at that time. The number of cows that were drinking, eating, lying down, perching, and standing was recorded.

Stall and environment measurements

At least 4 stalls were randomly selected in LACT and DRY pens in all farms that had a free stall housing system. Total length, curb to neck rail, neck rail down, and width were measured in these stalls. Temperature, RH, and WS, were recorded using a hygro-thermo-anemometer- light meter (Extech 45170, Extech Instruments, Nashua, NH). Temperature humidity index (**THI**) was calculated as follow: $THI = 0.8 \times T + [RH \times (T - 14.4)] + 46.4$ (McDowell et al., 1979).

Milk quality

Data about milk yield, bulk tank protein concentration, bulk tank fat concentration, SCC, and lactation somatic cell count score (**SCCS**) for the last test (e.g. closest to the visit) was obtained from herd management software's of 17 farms. Records of the proportion of cows

classified as healthy [SCC < 200,000 cells/mL in the last two previous milk test date (TD)], new mastitis cases [SCC > 200,000 cells/mL in the last TD and SCC < 200,000 cells/mL in the previous TD (PTD)], chronic cases (SCC > 200,000 cells/mL in the last TD and SCC > 200,000 cells/mL in the PTD), and cases of cows cured (SCC < 200,000 cells/mL in the last TD and SCC > 200,000 cells/mL in the PTD) were also acquired. In addition, yearly lactation milk yield, yearly bulk tank protein concentration, yearly bulk tank fat concentration, yearly SCC, and yearly SCCS were obtained from the same herd management software's of 17 farms. Also, milk yield, bulk tank protein concentration, and bulk tank fat concentration is reported by lactation stage (1 to 40 DIM, 41 to 100 DIM, 101 to 199 DIM, 200 to 305 DIM, and $\geq$ 306 DIM) and by parity (first, second, or third and greater parities) were obtained from 14 farms. Data were exported to Excel[®] (Microsoft Corp., Redmond, WA) to build a final dataset. Means and associated standard deviations for milk yield and composition from the last test day (e.g., closest to the visit) and yearly values are shown in Table 3.2.

Statistical Analyses

Statistical analysis was performed using SAS (v9.4 Institute Inc., Cary, NC). Mixed models were created (MIXED procedure) to analyze milk yield and milk components (e.g., last test closest to the visit and yearly, and by stage and by lactation). Also mixed models were created to analyze bedding quality (OM, DM, PS, PG, PSD, SA), barn measurements (total length, curb to neck rail, neck rail down, width), T, RH, THI, light, and wind speed.

Furthermore, the proportion of cows drinking, eating, lying down, perching, and standing were analyzed by creating mixed models. All questions in the questionnaire (e.g. goals, management, and dairy herd characteristic), health assessment (LS, VDS, MS, BCS, UHS, THS, LLS, ULS, and HS), and cow behavior (proportion of cows standing vs proportion of cows lying down) were analyzed as a binomial distribution (GLIMMIX procedure). Farm was used as a random effect. Region (N or S) and stage of lactation (DRY or LACT) and their interaction were used as fixed effects and included in the model when for the outcome variables: milk yield, tank protein concentration, tank fat concentration, SCC, SCCS, amount of healthy cows, new mastitis cases, chronic mastitis cases, cured mastitis cases, yearly milk yield, yearly tank protein concentration, yearly tank fat concentration, yearly SCC, and yearly SCC. Degrees of freedom method was Kenward-Rogers (Littell et al., 1998).

Residual distribution was evaluated for normality and homoscedasticity. Extreme outliers were deleted for SCC (n = 1), tank protein concentration (n = 1), tank milk fat concentration (n = 1), yearly tank milk protein concentration (n = 2), stall total length (n = 4), stall neck rail down (n = 3), sand DM (n = 1), PS (n = 3), SD (n = 1), milk protein concentration for cows with 41 – 100 DIM (n = 3), milk fat concentration for cows with 41–100 DIM (n = 1), milk protein concentration for cows with 101–199 DIM (n = 6), milk fat concentration for cows with 101 – 199 DIM (n = 2), milk protein concentration for cows with 100 – 199 DIM (n = 2), milk fat concentration for cows with 200 – 305 DIM (n = 2), milk protein concentration for cows with >

305 DIM ($n = 2$), and milk fat concentration for cows with > 305 DIM ($n = 1$). In order to meet criteria for normality and homoscedasticity, data were log-transformed (light, WS, OM, PG, SA, SCC, proportion of cows drinking, proportion of cows eating, proportion of cows lying, proportion of cows perching, and proportion of cows standing). Data on SCC presented in Table 3.8, and about cows' behavior (proportion of cows drinking, eating, lying down, perching, and standing) in Table 3.6 are presented back-transformed. Statistical significant was declared as P value lower than 0.05, and tendency declared as P value lower than 0.10 and greater than 0.05.

RESULTS

Management

Questionnaire description is detailed in Table 3.1 and the results for the management section are shown in Tables 3.3 and 3.4. There were no differences either between or within regions for short and long terms goals. The S had higher odds ($OR = 5.99$, $P = 0.003$) for not having standard operation protocols (SOP) than for having SOP at the farm. The S had lower odds ($OR = 0.08$, $P = 0.03$) for not identifying than for identifying cows with mastitis. Also, S tended ($P = 0.06$) to have higher odds ($OR = 3.63$) for not having SOP than for having SOP.

Health scores are shown in Table 3.5. North IL had higher odds ($OR = 2.81$, $P < 0.0001$) than S for having $MS > 2$. However, N had higher odds ($OR = 9.21$, $P < 0.0001$) for having $LLS > 1$ than $LLS = 1$; it had lower odds ($OR = 0.25$, $P < 0.0001$) for having $ULS > 1$ than for having

and ULS = 1. The S also had higher odds (OR = 8.00, $P < 0.0001$) for having LLS > 1 than LLS = 1; and lower odds (OR = 0.34, $P < 0.0001$) for having ULS > 1 than for having ULS = 1. Northern IL presented higher odds ($P < 0.03$) than S for having LS ≤ 2 .

Cow's behavior is shown in Table 3.6. Cows in N had higher odds (OR = 2.08, $P < 0.0001$) for cows being either perching or standing than S. Also, DRY cows had had higher odds (OR = 2.23, $P < 0.0001$) for cows being either perching or standing than LACT cows.

Bedding measurements and bedding quality are shown in Table 3.7. There were no differences on bedding measurements between regions or stages. South RH was higher (57.7 ± 2.1 %, $P = 0.0002$) than N (40.5 ± 3.6 %). Sand bedding OM was higher (5.4 ± 0.6 %, $P = 0.005$) for DRY cows than for LACT cows (2.8 ± 0.3 %). Sand bedding DM was higher (96.8 ± 0.5 %, $P = 0.01$) for S than for N regions (95.1 ± 0.5 %).

Milk Quality

Average values of milk yield and milk components are shown in Table 3.2. Milk yield and milk components values are shown in Table 3.8. Milk yield and milk components by parity groups are shown in Table 3.9. Milk yield was higher (42.0 ± 1.6 kg/d, $P < 0.00001$) for cows from 1 – 40 DIM in their second parity than in their first (30.5 ± 1.6 kg/d) or third parity (39.0 ± 1.6 kg/d). Milk yield was higher (48.5 ± 2.4 kg/d, $P = 0.0005$) for cows from 41 – 100 DIM in their third parity than in their first (34.7 ± 2.4 kg/d) or second parities (45.5 ± 2.4 kg/d).

Milk yield was significantly higher (42.8 ± 2.0 kg/d, $P = 0.01$) for cows from 101 – 199 DIM in their third lactation than in their first (34.8 ± 2.0 kg/d) or second lactation (40.6 ± 2.0 kg/d). Also, milk yield for cows from 101 – 199 DIM was higher (42.0 ± 2.0 kg/d, $P = 0.03$) for N than for S (36.8 ± 1.3 kg/d). Milk yield was significantly higher (35.1 ± 1.8 kg/d, $P = 0.02$) for cows from 200 – 365 DIM in N than in S (30.1 ± 1.2 kg/d). Also, milk yield for cows from > 365 DIM was higher (30.4 ± 1.3 kg/d, $P = 0.004$) in N than in S (25.6 ± 0.9 kg/d).

No association was found between bedding DM and SCC, but a positive association was found between bedding OM and SCC (Figure 1). The regression equation for OM % and SCC is as follows: $SCC = 133.75 + 15.00 \times OM$ ($P = 0.001$).

DISCUSSION

The aims of this study were to identify on-farm practices associated with milk quality in dairy farms and to identify potential geographical differences between the North and South regions in IL. We hypothesized that the compilation of differences among management practices would help to show that they do not have the same impact in N than in S IL.

Despite S being more likely to be able to identify cows with mastitis, it showed a tendency for being less likely to have a written SOP at the farm. Nonetheless, Stup et al. (2006) reported a negative relationship between having a SOP for SCC control and return on equity. The authors concluded that this negative relationship is due to the fact that SOP emerge as a

necessity of performance's improvements at dairy farms. On the other hand, the same study pointed a positive relationship between return on equity and employees who are continuously trained. Also, S had higher odds for not having SOP than for having SOP at the farm. Erskine et al. (2015) suggested that in spite of all improvements done at milking and cleaning barns, dairy farms employees are still not successfully doing a good job on mastitis control and prevention. Dairy farmers frequently think that they have a good mastitis management at their farms (Kuiper et al., 2005), and also it is common that owners and managers have unclear thoughts about employee training (Valeeva et al., 2007). Standard operation procedures can improve mastitis management practices (Stup, 2001); and also could shorten the gap generated by the lack of communication among personnel and managers (Valeeva et al., 2007).

Schreiner and Ruegg (2003) reported an association between linear SCC and leg hygiene score. In our study, both, N and S were less likely to have cleaner lower legs and more likely to have cleaner udders and upper legs. Furthermore, Ruud et al., (2010) reported similar results where cows' udders were cleaner than their legs and liquid manure increased the risk of dirtier teats. Cows in N were more likely to have solid manure than cows in S. It is important to frequently scrape alleys and to keep them as clean as possible since an association was found between the amount of manure in alleys and cows' udder and teats cleanliness (Magnusson et al., 2008). A hygienic milk production and healthy cows' udders can be guaranteed by assuring cow cleanliness (Schreiner and Ruegg, 2003; Ruud et al., 2010). South RH was higher than N.

However, there is not much information about how RH could impact on cows' cleanliness. Ruud et al. (2010) found that the risk of having dirtier legs increased for each 10 % unit increase in RH.

Northern IL was more likely to have $LS \leq 2$ than S. Also, cows were more likely to be either perching or standing in N than S. Studies found that cow behavior can be influenced by lameness, and that lame cows spent more time lying down (Walker et al., 2008; Chapinal et al., 2009) and less time eating (Gonzalez et al., 2008) than cows not lame. It is widely known that lame cows can have lower milk yields (Bicalho et al., 2008) because their welfare it is compromised (Whay et al., 2003). Bedding DM was higher for S than N, what could be associated with why cows were more likely to be lying down. Drissler et al. (2005) reported that cows can decrease the time that they spend lying down by about 10 min/d for every centimeter of sand bedding that has been reduced. Bedding OM was higher for DRY cows than for LACT cows. Bacterial counts on cows' teat ends are correlated with bedding bacterial counts (Zdanowicz, et al. 2004); and there was a positive association between the highest udder scores and environmental mastitis (Schreiner, et al., 2003). This is an important point of consideration since dry cows seem to be the ones most forgotten on dairy farms. Research indicates that approximately half of the new cases of mastitis are developed during the dry period (USDA, 2007).

There were differences between and within regions on milk yield. Milk yield in cows that were more than 101 DIM was greater in N than in S. Cows from 1 – 40 DIM in their second parity had higher milk yield than cows in their first or third parity in both regions. Furthermore, milk yield was higher for cows from 41 – 100 DIM in their third parity than in their first or second parities. Shortening dry periods ($< 6 - 8$ wk) will shift milk production from early lactation to weeks before calving. This shift could improve cows' fertility, health, and energy balance (van Knegsel et al., 2013). Dürr et al. (2007) reported that parity and stage of lactation should be taken in account when estimating losses generated by subclinical mastitis. Also, Seegers et al. (2003) proposed that milk yield can be lower in cows with mastitis during that lactation but also can affect next lactations.

CONCLUSION

There were geographical differences between N and S. South region was more likely to not have SOP than N. Both regions were more likely to have $LLS > 1$ and $ULS = 1$. Organic matter content in the sand used for bedding in dairy farms was positively associated with bulk tank SCC. Surveillance of bedding OM used in dairy farms may improve herd's milk quality (SCC).

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TABLES AND FIGURES

Table 3.1. Questionnaire's description.

Question	Category	
Goals		
Short term goals	Biological ¹	Economic ²
Long term goals	Keep the farm and improve some area	It depends on the family
Management		
If the farm has Standard operation practice (SOP)	Yes	No
How often the employees attend farming conferences	Equal or less than 3 per year	More than 3 per year
How many total employees are in your farm?	Equal or less than 10 employees	More than 10 employees
How many employees are feeding cows?	Equal or less than 40 %	More than 40 %
How many employees are breeding cows?	Equal or less than 40 %	More than 40 %
How many employees are milking cows?	Equal or less than 60 %	More than 60 %
How many employees are in charge of the farm's maintenance?	Equal or less than 10 %	More than 10 %
Does your farm have staff meetings?	Yes	No
Are the employees trained?	Yes	No
Do you have a milking SOP?	Yes	No
Are cows with mastitis identified?	Yes	No
If the farm's mastitis prevalence is known	Yes	No
Do you usually send samples for culture?	Yes	No
Does your farm purchase any % of replacement Heifers?	Yes	No
Does your farm track pregnancy rates by AI technicians?	Yes	No
Do your employees do BCS and BW in all cattle categories?	Yes	No
Dairy herd characteristics		
Which one breed of dairy cows best describes the majority of your herd?	Only one breed ⁵	More than one breed ⁶
Dairy herd size – the typical number of milking cows in the last year?	Equal or less than 300 cows	More than 300 cows
Number of heifers (12 to 24 months old) in the last year?	Equal or less than 300 heifers	More than 300 heifers
How much milk does the farm produce (cwt per farm) per day	Equal or less than 36 kg/d	More than 36 kg/d
How many times per day are cows milked?	Three times per day	Twice a day
What type of Milking Parlor do you have?	Not tie milking parlor ⁷	Tie milking parlor

¹ Biological: improve reproduction, milk production and or nutrition at the farm.

² Economic: improve facilities at the farm, and or have a better profit.

³ Biological: reproduction, mastitis, and or nutrition issues.

Table 3.1 (cont.)

⁴ Economic: facilities, and or personal issues.

⁵ Only one breed: either Jersey or Holstein.

⁶ More than one breed: either Jersey and Holstein or Holstein and other breeds.

⁷ Not tie milking parlor: parallel, herringbone or robot.

Table 3.2. Means and associated standard deviations for milk production analysis done in the last test closest to the visit, and yearly values in northern (n = 5) and southern farms (n = 12) in Illinois.

Variable	Region											
	North ¹				South ²				Overall ³			
	Mean	Median	SD ⁴	Range	Mean	Median	SD ⁴	Range	Mean	Median	SD ⁴	Range
Number of lactating cows ⁵	413	451	192	139 – 669	451	148	949	60 – 3444	439	191	793	60 – 3444
DIM ⁵	187	191	17	160 – 209	203	194	22	174 – 246	198	194	21	160 – 246
Milk yield ⁵ , kg/d	37.9	41.6	6.7	26.1 – 41.9	33.8	32.91	5.7	23.4 – 43.5	35.0	35.2	6.15	23.4 – 43.5
Tank protein concentration ⁵ , %	3.18	3.00	0.35	3.00 – 3.80	3.08	3.05	0.21	2.80 – 3.50	3.11	3.0	0.25	2.8 – 3.8
Tank fat concentration ⁵ , %	3.88	3.60	0.75	3.40 – 5.20	3.56	3.40	0.43	3.10 – 4.30	3.65	3.5	0.54	3.10 – 5.20
Somatic cell count/ml ⁶	196	189	21	172 – 219	207	182	109.3	102 – 526	204.0	183	91.4	102 – 526
Somatic cell count score ⁷	2.64	2.60	0.25	2.3 – 3.0	2.50	2.45	0.49	1.80 – 3.50	2.54	2.50	0.43	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	33.9	33.7	5.74	21.5 – 41.0
Tank yearly protein concentration, %	3.94	3.1	0.62	3.00 – 3.80	3.73	3.1	0.51	2.90 – 4.70	3.79	3.1	0.54	2.90 – 5.00
Tank yearly fat concentration, %	3.24	3.80	0.32	3.40 – 5.00	3.17	3.7	0.19	3.00 – 3.70	3.19	3.7	0.23	3.00 – 3.80
Yearly somatic cell count ⁶	193	208	37	136 – 231	236	219	79	113 – 409	223	214	71	113 – 409
Yearly somatic cell count score ⁷	2.64	2.60	0.32	2.20 – 3.10	2.66	2.65	0.43	1.90 – 3.50	2.65	2.60	0.39	1.90 – 3.50

¹ Cows in North region: n = 1396.

² Cows in South region: n = 5409.

³ Overall: cows in northern and southern Illinois (n = 6805).

⁴ SD: standard deviation.

⁵ Last test date related to the team's visit.

⁶ Somatic cell count = SCC × 1,000.

⁷ Somatic cell count score = linear SCS.

Table 3.3. Multivariate logistic mixed model of questions related to the farms' goal and management characteristics from northern (N) and southern (S) farms in Illinois

Variable	Region diff. ¹	Level	Coefficient	SE	OR	CL ²	P- value
Overall							
Farm's short term goals ³	N – S	Economical	0.98	1.02	2.67	0.31 – 22.76	0.34
Farm's long term goals ⁴	N – S	Depends on family	0.22	1.05	1.25	0.14 – 11.32	0.83
If the farm has SOP ⁵	N – S	No	– 0.18	1.33	0.83	0.05 – 13.78	0.89
Attendance to Conference Meetings ⁶	N – S	< 3/yr	– 1.32	1.22	0.27	0.02 – 3.47	0.29
Total of employees working at the farm ⁷	N – S	> 10 employees	– 0.31	1.27	0.73	0.05 – 10.67	0.81
Percentage of employees feeding cows ⁸	N – S	> 40 %	– 1.02	1.23	0.36	0.02 – 4.76	0.42
Percentage of employees breeding cows ⁹	N – S	> 40 %	– 0.69	1.24	0.50	0.04 – 6.84	0.58
Percentage of employees milking cows ¹⁰	N – S	> 60 %	0.10	1.03	1.11	0.13 – 9.67	0.92
Percentage of employees in charge of maintenance ¹¹	N – S	> 40 %	– 1.89	1.22	0.15	0.01 – 1.95	0.14
If the farm has staff meetings ¹²	N – S	No	– 1.28	1.03	0.28	0.03 – 2.42	0.22
It the employees are trained ¹³	N – S	No	– 1.89	1.22	0.15	0.01 – 1.95	0.14
If the farm has milking SOP ¹⁴	N – S	No	– 0.60	1.08	0.54	0.06 – 5.31	0.58
If cows with mastitis are identified ¹⁵	N – S	No	1.87	1.35	6.50	0.38 – 111.22	0.18
If the mastitis prevalence at the farm is known ¹⁶	N – S	No	– 0.12	1.06	0.89	0.09 – 8.33	0.91
If the farm send samples for culture ¹⁷	N – S	No	– 0.40	1.02	0.67	0.08 – 5.69	0.69
If the farm purchases any % of replacement Heifers ¹⁸	N – S	No	0.10	1.03	1.11	0.13 – 9.67	0.92
If the farm tracks pregnancy rates by AI technicians ¹⁹	N – S	No	– 0.40	1.02	0.67	0.07 – 5.69	0.69
If the employees do BCS and BW in all cattle categories ²⁰	N – S	No	– 0.22	1.04	0.80	0.09 – 7.24	0.83
Northern farms							
Farm's short term goals ³	-	Economical	0.69	0.87	1.99	0.22 – 18.54	0.46
Farm's long term goals ⁴	-	Depends on family	– 0.69	0.87	0.50	0.05 – 4.62	0.46
If the farm has SOP ⁵	-	No	1.61	1.09	5.00	0.30 – 83.93	0.20
Attendance to Conference Meetings ⁶	-	< 3/yr	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20
Total of employees working at the farm ⁷	-	> 10 employees	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20
Percentage of employees feeding cows ⁸	-	> 40 %	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20
Percentage of employees breeding cows ⁹	-	> 40 %	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20
Percentage of employees milking cows ¹⁰	-	> 60 %	0.69	0.87	1.99	– 1.53 – 2.92	0.46
Percentage of employees in charge of maintenance ¹¹	-	> 40 %	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20
If the farm has staff meetings ¹²	-	No	– 0.69	0.87	0.50	– 2.92 – 1.53	0.46
It the employees are trained ¹³	-	No	– 1.61	1.09	0.20	– 4.42 – 1.21	0.20

Table 3.3 (cont.)

If the farm has milking SOP ¹⁴	-	No	0.69	0.87	1.99	-1.53 – 2.92	0.46
If cows with mastitis are identified ¹⁵	-	No	- 0.69	0.87	0.50	- 2.92 – 1.53	0.46
If the mastitis prevalence at the farm is known ¹⁶	-	No	- 0.40	0.91	0.67	- 2.94 – 2.13	0.68
If the farm send samples for culture ¹⁷	-	No	- 0.69	0.87	0.50	-2.92 – 1.53	0.46
If the farm purchases any % of replacement Heifers ¹⁸	-	No	0.69	0.87	1.99	- 1.53 – 2.92	0.46
If the farm tracks pregnancy rates by AI technicians ¹⁹	-	No	- 0.69	0.87	0.50	- 2.92 – 1.53	0.46
If the employees do BCS and BW in all cattle categories ²⁰	-	No	0.69	0.87	0.50	-1.53 – 2.92	0.46
Southern farms							
Farm's short term goals ³	-	Economical	- 0.28	0.54	0.76	0.23 – 2.41	0.60
Farm's long term goals ⁴	-	Depends on family	- 0.91	0.59	0.40	0.11 – 1.43	0.14
If the farm has SOP ⁵	-	No	1.79	0.76	5.99	0.87 – 31.19	0.03
Attendance to Conference Meetings ⁶	-	< 3/yr	- 0.28	0.54	0.76	4.26 – 2.41	0.60
Total of employees working at the farm ⁷	-	> 10 employees	- 1.29	0.65	0.28	0.07 – 1.12	0.06
Percentage of employees feeding cows ⁸	-	> 40 %	- 0.59	0.56	0.55	0.17 – 1.86	0.31
Percentage of employees breeding cows ⁹	-	> 40 %	- 0.92	0.59	0.40	0.11 – 1.43	0.14
Percentage of employees milking cows ¹⁰	-	> 60 %	0.59	0.56	1.80	0.54 – 5.99	0.31
Percentage of employees in charge of maintenance ¹¹	-	> 40 %	0.29	0.54	1.34	0.41 – 4.26	0.60
If the farm has staff meetings ¹²	-	No	0.59	0.56	1.80	0.54 – 5.99	0.31
If the employees are trained ¹³	-	No	0.29	0.54	1.34	0.41 – 4.26	0.60
If the farm has milking SOP ¹⁴	-	No	1.29	0.65	3.63	0.90 – 15.03	0.06
If cows with mastitis are identified ¹⁵	-	No	- 2.56	1.04	0.08	0.01 – 0.73	0.03
If the mastitis prevalence at the farm is known ¹⁶	-	No	- 0.28	0.54	0.76	0.23 – 2.41	0.60
If the farm send samples for culture ¹⁷	-	No	- 0.28	0.54	0.76	0.23 – 2.41	0.60
If the farm purchases any % of replacement Heifers ¹⁸	-	No	0.59	0.56	1.79	0.54 – 5.99	0.31
If the farm tracks pregnancy rates by AI technicians ¹⁹	-	No	- 0.28	0.54	0.76	0.23 – 2.41	0.60
If the employees do BCS and BW in all cattle categories ²⁰	-	No	0.92	0.59	2.51	0.70 – 8.94	0.14

¹ Difference of regions least square means.² Odds Ratio 95% confidence limit.³ N [n = 6; biological (referent) = 2 and economical = 4] and S [n = 14; biological (referent) = 8 and economical = 6].⁴ N [n = 6; keep and improve some area or grow (referent) = 4, and depends on the family = 2] and S [n = 14; keep and improve some area or grow (referent) = 10, and depends on the family = 4].⁵ N [n = 6; yes (referent) = 1, and no = 5] and S [n = 14; yes (referent) = 3, and no = 14].⁶ N [n = 6; > 3/yr (referent) = 5, and ≤ 3/yr = 1] and S [n = 14; > 3/yr (referent) = 8, and ≤ 3/yr = 6].⁷ N [n = 6; ≤ 10 (referent) = 5, and > 10 = 1] and S [n = 14; ≤ 10 (referent) = 11, and > 10 = 3].⁸ N [n = 6; ≤ 40 % (referent) = 5, and > 40 % = 1] and S [n = 14; ≤ 40 % (referent) = 9, and > 40 % = 5].

Table 3.3 (cont.)

⁹ N [n = 6; ≤ 40 % (referent) = 5, and > 40 % = 1] and S [n = 14; ≤ 40 % (referent) = 10, and > 40 % = 4].

¹⁰ N [n = 6; ≤ 60 % (referent) = 2, and > 60 % = 4] and S [n = 14; ≤ 60 % (referent) = 5, and > 60 % = 9].

¹¹ N [n = 6; ≤ 10 (referent) = 5, and > 10 = 1] and S [n = 14; ≤ 10 (referent) = 6, and > 10 = 8].

¹² N [n = 6; yes (referent) = 4, and no = 2] and S [n = 14; yes (referent) = 5, and no = 9].

¹³ N [n = 6; yes (referent) = 5, and no = 1] and S [n = 14; yes (referent) = 6, and no = 8].

¹⁴ N [n = 6; yes (referent) = 2, and no = 4] and S [n = 14; yes (referent) = 3, and no = 11].

¹⁵ N [n = 6; yes (referent) = 4, and no = 2] and S [n = 14; yes (referent) = 13, and no = 1].

¹⁶ N [n = 5; yes (referent) = 3, and no = 2] and S [n = 14; yes (referent) = 8, and no = 6].

¹⁷ N [n = 6; yes (referent) = 4, and no = 2] and S [n = 14; yes (referent) = 13, and no = 1].

¹⁸ N [n = 5; yes (referent) = 2, and no = 3] and S [n = 14; yes (referent) = 5, and no = 9].

¹⁹ N [n = 5; yes (referent) = 4, and no = 1] and S [n = 14; yes (referent) = 8, and no = 6].

²⁰ N [n = 5; yes (referent) = 2, and no = 3] and S [n = 14; yes (referent) = 4, and no = 10].

Table 3.4. Multivariate logistic mixed model of questions related to the farms' herd characteristics from northern (N) and southern (S) farms in Illinois

Variable	Region diff. ¹	Level	Coefficient	SE	OR	CL ²	P- value
Overall							
Breed that describes the majority of the herd ³	N – S	> 1 breed	– 0.31	1.27	0.73	0.05 – 10.67	0.81
Number of cows ⁴	N – S	> 300	1.28	1.03	3.60	0.41 – 31.34	0.22
Number of heifers ⁵	N – S	> 300	1.09	1.15	3.00	0.26 – 33.94	0.35
Milk production per farm (kg/d) per day ⁶	N – S	< 36	1.61	1.05	5.00	0.55 – 45.28	0.14
Times milk per day ⁷	N – S	2x/d	– 0.79	1.12	0.45	0.04 – 4.89	0.48
Type of milking parlor ⁸	N – S	Tie	0.18	1.33	1.20	0.07 – 19.84	0.89
Northern farms							
Breed that describes the majority of the herd ³	-	> 1 breed	– 1.61	1.09	0.20	0.01 – 335	0.21
Number of cows ⁴	-	> 300	0.69	0.87	1.99	0.22 – 18.54	0.46
Number of heifers ⁵	-	> 300	0.69	0.87	1.99	0.05 – 4.62	0.46
Milk production per farm (kg/d) per day ⁶	-	> 36	0.69	0.87	1.99	0.05 – 4.62	0.46
Times milk per day ⁷	-	2x/d	0.40	0.91	1.49	0.12 – 3.35	0.68
Type of milking parlor ⁸	-	Tie	– 1.61	1.09	0.20	0.01 – 3.35	0.20
Southern farms							
Breed that describes the majority of the herd ³	-	> 1 breed	– 1.29	0.65	0.28	0.07 – 1.12	0.06
Number of cows ⁴	-	> 300	– 0.59	0.56	0.55	0.17 – 1.86	0.31
Number of heifers ⁵	-	> 300	– 1.79	0.76	0.17	0.03 – 0.87	0.03
Milk production per farm (kg/d) per day ⁶	-	> 36	– 0.91	0.59	0.4	0.11 – 1.43	0.14
Times milk per day ⁷	-	2x/d	1.20	0.66	3.32	0.79 – 13.87	0.09
Type of milking parlor ⁸	-	Tie	– 1.79	0.76	0.17	0.03 – 0.87	0.03

¹ Difference of regions least square means.

² Odds Ratio 95% confidence limit.

³ N [n = 6; 1 breed (referent) = 5 and > 1 breed = 1] and S [n = 14; 1 breed (referent) = 11 and > 1 breed = 3].

⁴ N [n = 6; ≤ 300 (referent) = 2 and > 300 = 4] and S [n = 14; ≤ 300 (referent) = 9 and > 300 = 5].

⁵ N [n = 6; ≤ 300 (referent) = 4 and > 300 = 2] and S [n = 14; ≤ 300 (referent) = 12 and > 300 = 2].

⁶ N [n = 6; > 36 (referent) = 2 and ≤ 36 = 4] and S [n = 14; > 36 (referent) = 2 and ≤ 36 = 4].

⁷ N [n = 5; 3x/d (referent) = 2 and 2x/d = 3] and S [n = 13; 3x/d (referent) = 3 and 2x/d = 10].

⁸ N [n = 5; not tie (referent) = 5 and tie = 1] and S [n = 13; not tie (referent) = 12 and tie = 2].

Table 3.5. Multivariate logistic mixed model of hygiene and health scores characteristics from northern (N) and southern (S) farms in Illinois

Variable	n ¹	Region diff. ²	Level ³	Coefficient	SE	OR	CL ⁴	P- value
Overall (n = 20)								
Udder hygiene score ⁵	401	N – S	Not clean	– 0.32	0.26	0.71	0.42 – 1.22	0.21
Teat hygiene score ⁶	364	N – S	Not clean	0.33	0.25	1.39	0.83 – 2.32	0.19
Lower leg hygiene score ⁷	431	N – S	Not clean	0.14	0.34	1.15	0.57 – 2.29	0.67
Upper leg hygiene score ⁸	412	N – S	Not clean	– 0.29	0.25	0.74	0.44 – 1.24	0.24
Hock score ⁹	375	N – S	Not clean	0.74	0.23	2.11	1.33 – 3.36	0.002
Lameness score ¹⁰	1125	N – S	Lame	– 0.45	0.21	0.63	0.41 – 0.98	0.03
Vaginal discharge ¹¹	1212	N – S	Clean	0.48	0.43	1.61	0.68 – 3.82	0.27
Manure score ¹²	1036	N – S	≤ 2	– 1.03	0.14	0.36	0.27 – 0.48	< 0.0001
Body condition score ¹³	1123	N – S	Not desirable	0.16	0.28	1.18	0.67 – 2.07	0.56
Northern Farms (n = 6)								
Udder hygiene score ¹⁴	124	N – S	Not clean	– 1.38	0.22	0.25	0.16 – 0.41	< 0.0001
Teat hygiene score ¹⁵	93	N – S	Not clean	– 0.41	0.21	0.66	0.41 – 1.07	0.08
Lower leg hygiene score ¹⁶	143	N – S	Not clean	2.22	0.28	9.21	4.85 – 17.46	< 0.0001
Upper leg hygiene score ¹⁷	138	N – S	Not clean	– 1.37	0.21	0.25	0.16 – 0.41	< 0.0001
Hock score ¹⁸	117	N – S	Not clean	– 0.02	0.18	0.98	0.65 – 1.48	0.93
Lameness score ¹⁹	331	N – S	Lame	– 2.27	0.19	0.10	0.07 – 0.15	< 0.0001
Vaginal discharge ²⁰	331	N – S	Clean	– 3.58	0.34	0.04	0.01 – 0.06	< 0.0001
Manure score ²¹	355	N – S	≤ 2	– 1.14	0.12	0.32	0.25 – 0.41	< 0.0001
Body condition score ²²	331	N – S	Not desirable	– 2.74	0.23	0.06	0.04 – 0.11	< 0.0001
Southern Farms (n = 14)								
Udder hygiene score ²³	277	N – S	Not clean	– 1.05	0.14	0.35	0.26 – 0.47	< 0.0001
Teat hygiene score ²⁴	271	N – S	Not clean	– 0.75	0.13	0.47	0.36 – 0.62	< 0.0001
Lower leg hygiene score ²⁵	288	N – S	Not clean	2.08	0.19	8.00	5.42 – 11.82	< 0.0001
Upper leg hygiene score ²⁶	274	N – S	Not clean	– 1.07	0.14	0.34	0.26 – 0.46	< 0.0001
Hock score ²⁷	258	N – S	Not clean	– 0.76	0.13	0.47	0.35 – 0.61	< 0.0001

Table 3.5 (cont.)

Lameness score ²⁸	794	N – S	Lame	– 1.82	0.10	0.16	0.13 – 0.20	<0.0001
Vaginal discharge ²⁹	881	N – S	Clean	– 4.05	0.26	0.02	0.01 – 0.08	<0.0001
Manure score ³¹	681	N – S	≤ 2	-0.11	0.08	0.90	0.77 – 1.05	0.16
Body condition score ³²	792	N – S	Not desirable	– 2.91	0.16	0.05	0.04 – 0.08	<0.0001

¹ Cows used from both N and S treatments

² Difference of regions least squares means

³ Udder Hygiene Score was based on a hygiene score >1 (not clean) and score = 1 (clean, referent). Teat Hygiene Score was based on a hygiene score >1 (not clean) and score = 1 (clean, referent). Lower Leg Hygiene Score was based on a hygiene score >1 (not clean) and score = 1 (clean, referent). Upper Leg Hygiene Score was based on a hygiene score >1 (not clean) and score = 1 (clean, referent). Hock Score was based on a hygiene score >1 (not clean) and score = 1 (clean, referent). Lameness Score was based on a hygiene score > 2 (lame) and score ≤ 2 (not lame, referent). Vaginal discharge was based on a vaginal discharge score >1 (not clean) and score = 1 (clean, referent). Manure Score was based on a manure score ≤ 2 (diarrhea) and score > 2 (not diarrhea, referent). Body Condition Score was based on a scale < 2.5 and > 4.0 (not desirable) and scale 2.5 to 4.0 (desirable, referent).

⁴ Odds Ratio 95% Confidence Limit.

⁵ N (n = 124; clean = 99, and not clean = 25) and S (n = 277; clean = 205, and not clean = 72).

⁶ N (n = 93; clean = 56, and not clean = 37) and S (n = 271; clean = 184, and not clean = 87).

⁷ N (n = 143; clean = 14, and not clean = 129) and S (n = 288; clean = 32, and not clean = 256).

⁸ N (n = 138; clean = 110, and not clean = 28) and S (n = 274; clean = 204, and not clean = 70).

⁹ N (n = 117; clean = 59, and not clean = 58) and S (n = 258; clean = 176, and not clean = 82).

¹⁰ N (n = 331; not lame = 300, and lame = 31) and S (n = 794; not lame = 683, and lame = 111).

¹¹ N (n = 331; clean = 322, and not clean = 9) and S (n = 881; clean = 866, and not clean = 15).

¹² N (n = 355; score > 2 = 269, and score ≤ 2 = 86) and S (n = 681; score > 2 = 359, and score ≤ 2 = 322).

¹³ N (n = 331; desirable = 322, and not desirable = 9) and S (n = 792; desirable = 751, and not desirable = 41).

Table 3.6. Least squares means and associated standard errors for cow's behavior observed different pens in northern and southern Illinois, by regions, and by lactation stage

Variable	Region						SE	P- value		
	North			South				Region	Stage ¹	Region × Stage ⁷
	Lactating ¹	Dry ²	Overall ³	Lactating ⁴	Dry ⁵	Overall ⁶				
Cows drinking, %	5.4	7.6	6.5	2.8	7.1	4.9	0.41	0.32	0.03	0.49
Cows eating, %	31.7	39.8	35.8	28.1	37.6	32.8	10.0	0.69	0.24	0.92
Cows lying, %	37.3	35.6	36.4	45.5	31.6	38.5	11.5	0.81	0.36	0.47
Cows perching, %	11.8	9.6	10.7	7.3	6.7	6.9	4.1	0.22	0.65	0.78
Cows standing, %	15	7.4	11.2	16.2	17.1	16.7	8.7	0.39	0.61	0.51

¹ Lactating cows: n = 1241.

² Dry cows: n = 163.

³ Overall: lactating and dry cows: n = 1404.

⁴ Lactating cows: n = 4590.

⁵ Dry cows: n = 278.

⁶ Overall: lactating and dry cows: n = 4868.

⁷ Stage: lactating and dry cows.

Table 3.7. Least squares means and associated standard errors for stalls' measurements done in different pens in northern farms (n = 6) and southern farms (n = 14) in Illinois, by regions, and by lactation stage

Variable	Region						SE	P- value		
	North			South				Region	Stage ¹	Region × Stage ¹
	Lactating ²	Dry ³	Overall ⁴	Lactating ⁵	Dry ⁶	Overall ⁷				
Stalls Measurements										
Total length, cm	237.1	232.4	234.8	229.4	231.6	230.5	9.2	0.46	0.55	0.83
Curb to Neck Rail, cm	174.8	178.4	176.6	170.3	177.5	173.9	14.7	0.75	0.52	0.83
Neck Rail Down, cm	118.5	121.2	119.9	111.1	113.3	112.2	9.2	0.19	0.67	0.96
Width, cm	121.0	132.1	126.6	123.2	125.6	124.4	7.4	0.65	0.17	0.37
Temperature, °C	27.0	27.8	27.4	28.6	27.5	28.0	2.1	0.67	0.90	0.48
Relative Humidity, %	42.5	38.5	40.5	59.0	56.3	57.7	6.6	0.0002	0.42	0.87
Temperature Humidity Index, °C	36.8	38.0	37.4	35.2	35.6	35.4	1.9	0.09	0.51	0.73
Light log – transformed, foot candles	4.5	4.2	4.3	4.3	3.8	4.1	0.76	0.61	0.40	0.82
Wind log – transformed, m/s	– 0.30	– 0.15	– 0.20	– 0.15	– 0.50	– 0.35	0.92	0.83	0.83	0.64
Bedding Quality										
Organic Matter log – transformed, %	1.05	1.6	1.3	0.8	1.4	1.10	0.26	0.21	0.005	0.95
Dry Matter, %	95.9	94.3	95.1	96.4	97.2	96.8	0.90	0.01	0.51	0.07
Particle Size, microns	349.3	486.6	417.9	453.3	537.5	495.4	88.8	0.26	0.11	0.69
Particle per Gram log – transformed	12.5	12.1	12.3	11.5	11.2	11.4	1.0	0.23	0.63	0.92
Standard Deviation	2.2	2.1	2.1	2.0	2.1	2.1	0.09	0.38	0.81	0.15
Surface Area log – transformed, cm ² /gram	5.06	4.97	5.0	5.0	4.8	4.8	0.24	0.38	0.48	0.84

¹Stage: lactating and dry pens.

²Lactating pens: stalls measurements (n = 13) and bedding quality (n = 13).

³Dry pens: stalls measurements (n = 2) and bedding quality (n = 5).

⁴Overall: lactating and dry pens: stalls measurements (n = 15) and bedding quality (n = 18).

⁵Lactating pens: stalls measurements (n = 26) and bedding quality (n = 27).

⁶Dry pens: stalls measurements (n = 6) and bedding quality (n = 4).

⁷Overall: lactating and dry pens: stalls measurements (n = 32) and bedding quality (n = 31).

Table 3.8. Least squares means and associated standard errors for milk production analysis done in the last test closest to the visit, and yearly values in northern farms (n = 5) and southern farms (n = 12) in Illinois

Variable	Region		SE ³	P- value
	North ¹	South ²		
Milk yield, kg/d	38.0	33.8	3.2	0.21
Tank protein concentration ⁴ , %	3.02	3.08	0.11	0.59
Tank fat concentration ⁴ , %	3.55	3.56	0.22	0.97
SCC/ml ¹	195	173	50.18	0.34
Somatic cell count score ⁵	2.64	2.50	0.23	0.55
Proportion of healthy cows, %	71.9	75.9	5.9	0.52
Proportion of cows with new mastitis cases, %	7.1	7.6	2.21	0.83
Proportion of cows with chronic mastitis cases, %	14.4	10.6	1.63	0.22
Proportion of cows with cured mastitis cases, %	6.50	6.10	1.07	0.84
Yearly average milk yield, kg/d	36.7	32.7	2.9	0.20
Tank yearly protein concentration, %	3.10	3.12	0.05	0.76
Tank yearly fat concentration, %	3.94	3.73	0.29	0.48
Yearly somatic cell count ⁵	193	236	37.6	0.27
Yearly somatic cell count score ⁶	2.64	2.65	0.21	0.94

¹ Cows in North region: n = 1396.

² Cows in South region: n = 5409.

³ SE: standard error of the mean.

⁴ Last test date related to the team's visit.

⁵ Somatic cell count = SCC x 1,000.

⁶ Somatic cell count score = linear SCS.

Table 3.9. Least squares means and associated standard errors for milk production analysis done in the last test closer to the visit, and yearly values in northern farms (n = 4) and southern farms (n = 10) in Illinois

Variable	Region								SE	P- value		
	North				South					Region	Stage ¹	Region × Stage ¹
	1 st Parity	2 nd Parity	3 rd or more parity	Overall ⁸	1 st Parity	2 nd Parity	3 rd or more parity	Overall ⁹				
Cows from one to forty days in milk ³												
Milk yield ²	30.0	44.0	41.0	38.3	31.0	40.0	36.9	36.0	2.6	0.21	< 0.0001	0.45
Protein %	3.0	3.1	3.1	3.1	3.0	3.0	3.0	3.0	0.1	0.35	0.77	0.84
Fat %	4.1	4.0	4.0	4.1	3.6	3.9	4.0	3.8	0.27	0.25	0.75	0.55
Cows from forty one to a hundred days in milk ⁴												
Milk yield ²	35.7	47.2	60.0	44.6	33.8	43.9	46.0	41.1	4.0	0.22	0.0005	0.90
Protein %	3.0	2.8	2.8	2.8	2.9	2.9	2.8	2.9	0.11	0.77	0.37	0.31
Fat %	3.8	3.3	3.7	3.6	3.5	3.3	3.1	3.3	0.27	0.18	0.21	0.43
Cows from one hundred and one to one hundred ninety nine days in milk ⁵												
Milk yield ²	36.6	43.9	45.4	42.0	32.9	37.4	40.2	36.8	3.3	0.03	0.01	0.88
Protein %	3.1	3.0	3.0	3.0	3.0	3.0	2.9	3.0	0.07	0.46	0.36	0.93
Fat %	3.4	3.5	3.9	3.6	3.5	3.5	3.3	3.4	0.26	0.33	0.73	0.28
Cows from two hundred to three hundred and five days in milk ⁶												
Milk yield ²	34.8	35.9	34.6	35.1	30.7	29.7	30.	30.1	3.2	0.02	0.98	0.92
Protein %	3.1	3.2	3.2	3.2	3.1	3.3	3.3	3.2	0.12	0.36	0.58	0.99
Fat %	3.7	3.5	3.7	3.6	3.7	3.8	3.7	3.7	0.23	0.57	0.96	0.75
Cows with more than three hundred and six days in milk ⁷												
Milk yield ²	32.0	30.7	28.7	30.4	27.3	24.5	25.1	25.6	2.3	0.004	0.36	0.81
Protein %	3.5	3.4	3.3	3.4	3.4	3.5	3.4	3.4	0.12	0.77	0.63	0.62
Fat %	4.2	4.2	3.7	4.0	4.0	4.0	3.9	4.0	0.25	0.67	0.28	0.65

¹ Stage: cows from 1 to 40 DIM, from 41 to 100 DIM, from 101 to 199 DIM, from 200 to 305 DIM, and > 306 DIM.

² Milk yield: average (kg/d)

³ Cows from 1 to 40 DIM: North: 1st parity (n = 64), 2nd parity (n = 42), > 3rd parity (n = 31). South: 1st parity (n = 156), 2nd parity (n = 179), > 3rd parity (n = 167).

⁴ Cows from 41 to 100 DIM: North: 1st parity (n = 80), 2nd parity (n = 47), > 3rd parity (n = 50). South: 1st parity (n = 304), 2nd parity (n = 258), > 3rd parity (n = 207).

⁵ Cows from 101 to 199 DIM: North: 1st parity (n=114), 2nd parity (n=98), > 3rd parity (n=130). South: 1st parity (n=560), 2nd parity (n=428), > 3rd parity (n=407).

Table 3.9 (cont.)

⁶ Cows from 200 to 305 DIM: North: 1st parity (n = 137), 2nd parity (n = 91), > 3rd parity (n = 150). South: 1st parity (n = 535), 2nd parity (n = 370), > 3rd parity (n = 480).

⁷ Cows > 305 DIM: North: 1st parity (n = 63), 2nd parity (n = 55), > 3rd parity (n = 83). South: 1st parity (n = 449), 2nd parity (n = 279), > 3rd parity (n = 254).

⁸ Overall: first lactation, second lactation, third and more lactation in North Illinois.

⁹ Overall: first lactation, second lactation, third and more lactation in South Illinois.

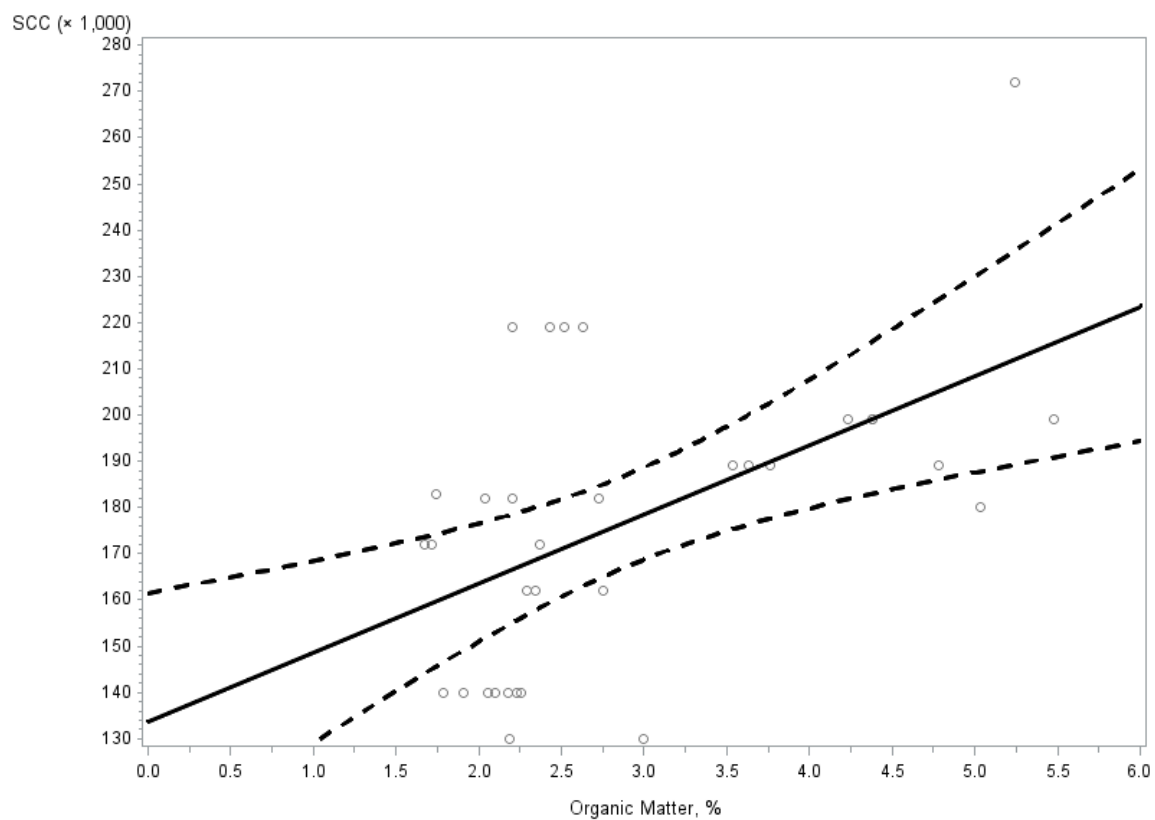


Figure 3.1. Association between bedding organic matter and somatic cell counts (×1,000 cells/mL) in 17 farms throughout Illinois. $SCC = 133.75 + 15.00 \times OM$ ($P = 0.001$)

OVERALL SUMMARY AND CONCLUSIONS

The world dairy industry needs to find efficient and profitable techniques to face the expected 9.3 billion inhabitants projected by the year 2030 having the same or less amount of good quality land. Also, this growth in food production will happen under a scenario where consumers call for cheaper and better quality food that support their personal values. If consumers' biggest concerns about antibiotic residues and hormone presence in milk keep growing, the dairy industry will have to develop new management strategies that allow them to grow and stay profitable without incurring their uses.

Dairy operations' reproductive and economic performance is vastly influenced by their long-term reproductive strategy. Although higher milk production has been associated with lower reproductive performance, intensive selection for high milk production is not the only factor affecting cows' reproductive performance. Management practices such as heat detection efficiency, nutrition, BCS, negative energy balance, postpartum uterine infections, and udder health are also involved in cows' reproductive performance and therefore affect dairy farm profitability. Management practices on dairies play an important role on milk quality. Including sand bedding analysis as a routine management practice may improve milk quality (e.g., SCC) in dairy farms.

There are opportunities to improve nutritional, reproductive, young stock, facilities management, and milk quality. Illinois University extension programs and policy makers should

implement targeted dairy improvement programs to enhance performance and profitability of IL dairy farms. For example, the Dairy Focus Team has developed a personal report back (APPENDIX A) to each one of the 20 dairy farms visited where all the farm's threats and opportunities were highlighted. Furthermore, a newsletter (<http://dairyfocus.illinois.edu/content/dairy-focus-newsletter>, and YouTube tutorials (<https://www.youtube.com/user/DairyFocusAtIllinois>) are offered as a tool that cover some of these opportunities mentioned before.

Certainly the Dairy Focus Team still has much to accomplish. The next objective should be to better understand if the differences between N and S are due to the proximity of these points to different extension programs (e.g., N to Wisconsin's extension programs, and S to Illinois' extension programs). It is also necessary to develop a survey in order to better classify and describe IL dairies since the last USDA reports' data do not include them.

APPENDIX A. PROJECT REPORT

PROJECT REPORT

Evaluation of Best Practices Associated with
Enhanced Performance in Illinois Dairy
Farms – A Dairy Focus Team Approach



DAIRY FOCUS

FARM 620

9/10/2014



Farmer Name



Localization: Shannon, IL

Contact: confidential

E-mail: confidential

Address: confidential

Visit date: 5/30/2014 AM

Production: 80 lbs./cow/d

Calves and Young Stock



Strengths, Weaknesses, Opportunities, and Threats:

- Calves all receive 2 gal / day pasteurized milk
- Poor ventilation in calf barn
- Clean buckets every day at calves

Wet Calves	Desirable	Observed
Temperature (° F)	< 70	81.1
Humidity (%)	< 70	54.8
THI [*]	< 68	75.4
Wind ^{**} (m/s)	> 0.5	0
Light (foot candles)	> 10	60.5

* THI = Temperature – [(0.55 – (0.55 x Humidity/100)) x (Temperature – 58)]

** With this value, the number of animals in the barn, and the dimensions of the barn (volume) the total cubic feet per minute (CFM) and most important, dividing it by the number of animals in the barn you can find the CFM/animal.

<http://www.engineering.com/calculators/airflow.htm>

Minimum Ventilation Rates for Dairy Barns			
	CFM per animal		
	Winter	Mild Weather	Summer
Calves 0-2 months	15	50	100
Heifers			
2 - 12 months	20	60	130
12 - 24 months	30	80	180
Cows	50	170	500

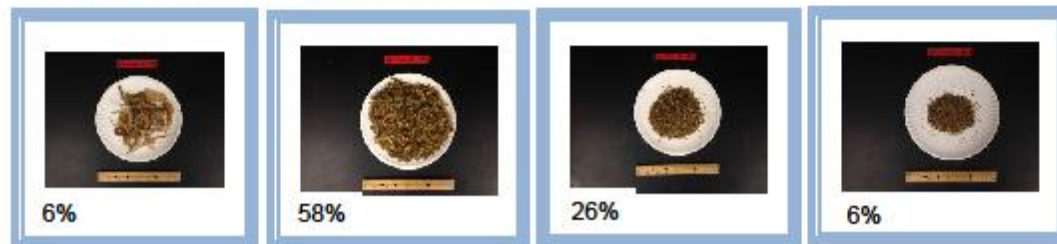
Nutrition



Strengths, Weaknesses, Opportunities, and Threats:

- Feed for 3-5% refusals and are not wasted by feeding to heifers
- Cleaning feed bunks
- Push up feed more often
- Decrease DA %

Corn Silage		Desirable	Your Corn Silage
Dry mater (%)		30 – 35	33.1
Density (lbs/ft)		≥ 15	10.2
Particle size	0.75 _{Inch}	3 – 8	22
	0.31 _{Inch}	45 – 65	55
	0.16 _{Inch}	20 – 30	14
	pan	< 10	9

Your corn silage sample*Ideal corn silage sample from an IL dairy farm*

Ideal corn silage sample from an IL dairy farm

58%

26%

10%

TMR		Desirable	Dry Cows	Lactation
Dry mater (%)		45 – 55	45.2	49.3
Particle Size (%)	0.75 _{Inch}	> 10	41	58
	0.31 _{Inch}	40 – 50	37	19
	0.16 _{Inch}	< 35	12	10
	pan	< 20	10	13

Facilities



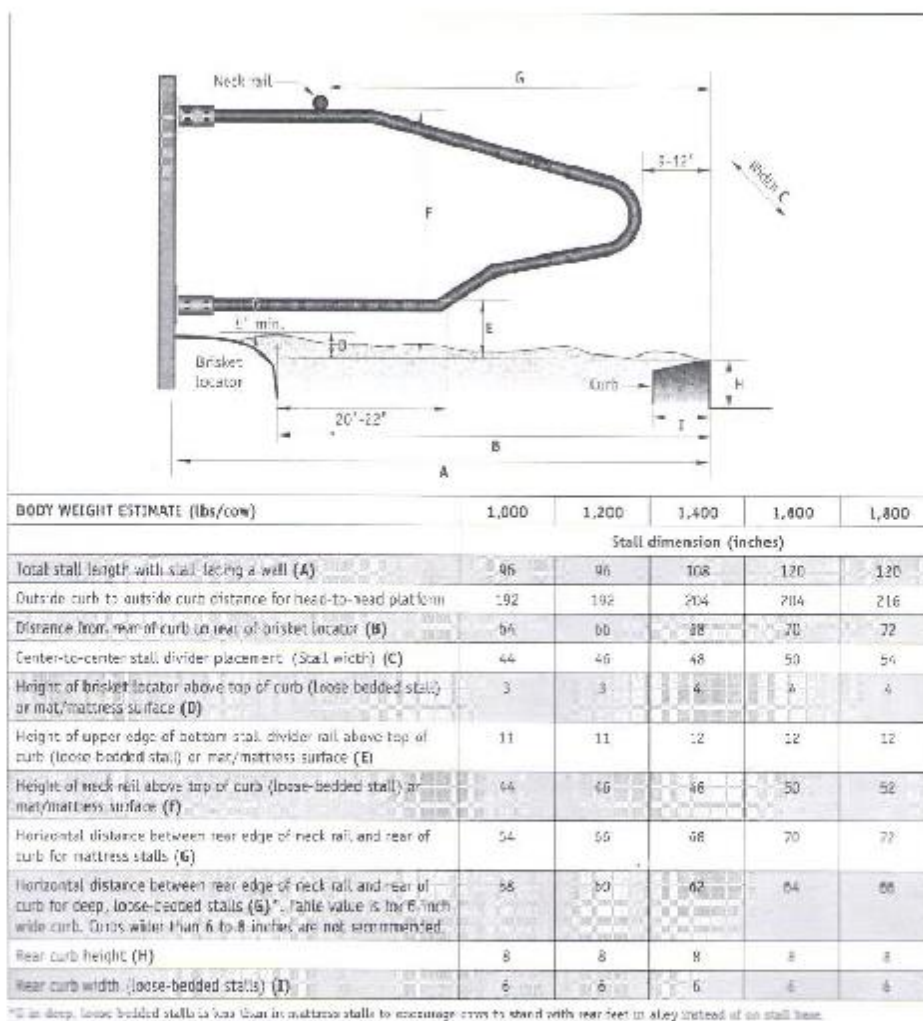
Strengths, Weaknesses, Opportunities, and Threats:

- Ventilation in lactation pen
- Poor access to drinking water for dry cows
- Improve misting capacity of sprinklers and place fans over feed bunk
- Improve comfort in free stalls
- Inadequate shelter and bedding provided to dry cows

Lactating	Desirable	Lactating Pen 1	
		@ Bunker	@ Bed
Temperature (° F)	< 70	NE	81.3 ± 0.2
Humidity (%)	< 70	NE	49.8 ± 0.2
THI	< 68	NE	74.9
Wind (m/s)	> 0.5	NE	2.2 ± 0.4
Light (foot candles)	> 20	NE	218.3 ± 337.0

Behavior	Lactation		Far Off	
	# of animals	%	# of animals	%
Drinking	1	1	2	9
Eating	22	18	20	87
Lying Down	90	74	1	4
Perching	8	7	0	0
Standing	0	0	0	0

Stalls	Lactating
Total length inch	100.2 $\pm$ 2.5
Curb to Neck Rail inch	66.3 $\pm$ 1.5
Neck Rail Down inch	48.3 $\pm$ 2.1
Bed Width inch	49.5. $\pm$ 1.7
Curb to Brisket Board inch	NE
BB to neck rail distance inch	NE



Bedding	Desirable	Lactation
DM (%)	> 95	97.7
Organic Matter (%)	≤ 3	2.7
Particle Size microns	---	386.8 ± 2
Particles per gram	---	128723.5

Management



Strengths, Weaknesses, Opportunities, and Threats:

- Access to creek is an environmental risk
- Access to outside pasture immediately after milking

	Desirable	Items	Dry	Lactation
BCS (1 – 5) 1 – Extremely thin 2 – Extremely fat	See Table Below	AVG $\pm$ SD	3.47 $\pm$ 0.3	3.4 $\pm$ 0.3
		% $\geq$ 4	0	0
		% $\leq$ 2.5	0	0
Lame Score (1 – 5) 1- Normal 2- Mildly Lame 3- Moderate Lame 4- Lame 5- Severely Lame	< 2	AVG $\pm$ SD	1 $\pm$ 0	1 $\pm$ 0
		% $\geq$ 2	0	0

At least 15 cows were evaluated per pen

			BCS		
			Goal	Min	Max
Dairy Focus – Farm Visit 2014	Stage of Lactation	DIM			
	Calving		3.50	3.25	3.75
	Early Lactation	1 to 30	3.00	2.75	3.25
	Peak Milk	31 to 100	2.75	2.50	3.00
	Mid Lactation	101 to 200	3.00	2.75	3.25
	Late Lactation	201 to 300	3.25	3.00	3.75
	Dry Off	> 300	3.50	3.25	3.75
	Dry		3.50	3.25	3.75

13

	Desirable	Items	Dry	Lactation
Manure Score (1 – 5) 1 – Very Liquid 2 – Runny and does not form a distinct pile 3 – Porridge-like appearance 4 – Manure is thicker 5 – Firm fecal balls	Fresh cows (score 2 to 2 ½)	AVG	2.8	2.8
	Early lactation cows (score 2 ½ to 3) Late lactation cows (score 3 to 3 ½) Far off dry cows (score 3 to 4) Close up dry cows (score 2 ½ to 3 ½)	% ≤ 2	28.6	25
Uterine discharge (0 – 3) 0 – Clear mucus 1 – Clear mucus with some flecks of white pus 2 – Less than 50% of white or cream pus 3 – More than 50% of white, cream or bloody pus	≤ 1	AVG ± SD	0	0.2 ± 0.8
		% ≥ 2	0	6.7

	1 / N		2 / S		3 / R		4 / VR	
	N	%	N	%	N	%	N	%
Teat Condition	2	15	8	62	3	23	0	0
Udder Hygiene	8	80	2	20	0	0	0	0
Teat Hygiene	6	50	3	25	3	25	0	0
Lower Leg Hygiene	1	6	9	50	8	44	0	0
Upper Leg Hygiene	11	79	3	21	0	0	0	0
Hock Scores	7	100	0	0	0	0	0	0

Hygiene
 1- Free of Manure
 2- Slightly Dirty
 3- Mod covered
 4- Caked on

Hock
 1- No swelling, no hair missing
 2- No swelling, bald spots
 3- Swelling and Lesions

Teat Condition
 N- Smooth Teat End
 S- Slightly Ring
 R- Rough ring
 VR- Very rough Ring

Suggestions

- Water drench all fresh cows after calving to decrease % of displaced abomasum
- Shorten distance between neck rail and brisket board to 2" apart.

The Dairy Focus Lab would like to thank all the dairy farmers for the attention and for providing the data and materials collected. *Thank you.*