The Impact of Management on the Health and Wellbeing Of Dairy Cattle on Organic and Small Conventional Farms

By

Meghan Brockmeyer-Bergman

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DEDICATION

I would like to dedicate this thesis to my family, especially my husband Michael. Without his unconditional love and continuous support this achievement would not have been possible.

To my parents, who have always believed in me, provided an amazing support network and encouraged me to follow my dreams. I am truly blessed to have been raised with the instilment of hard work, dedication and a passion for the dairy industry.

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INTRODUCTION

Animal wellbeing is becoming ever more important to consumers and dairy producers in the United States. Many programs have been developed in recent years to meet the consumer's concerns with assessments and third party audits of animal based measures and management practices on dairy farms; however, no two programs are the same. There is a need for scientific research to develop a standardized way to measure dairy cattle wellbeing at the farm level.

Historically, there has not been a single defined standard for managing dairy cattle and therefore, farmers have been independently making important management decisions. Although, legal regulations do exist for the mistreatment of animals. In the United States organic and conventional dairies can be managed quite differently. Although, there has been an increase in the number of organic dairies, little is known about how the diversity of management practices impacts dairy cattle wellbeing.

The objectives of this thesis were to determine management practices that affect dairy cattle wellbeing, compare current dairy cattle welfare programs and assess management practices associated with dairy cattle wellbeing across organic dairy farms and similarly-sized conventional dairies. Chapter 1 is a literature review on management practices and animal based measures which may be used for the assessment of animal wellbeing. Chapter 2 compares three welfare programs designed to assess animal wellbeing, as well as management practices associated with these welfare program requirements on organic and similarly sized conventional farms. Chapter 3 provides developed scores for the welfare assessment of calf health, calf management practices and adult cow health.

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Chapter 1

1.0 LITERATURE REVIEW

1.1 DEFINITION OF DAIRY CATTLE WELLBEING

Animal welfare is a concern for dairy producers as well as for consumers of dairy products (Spoolder, 2007). In recent years, several welfare audit systems have been developed in the United States (Table 1.1), however it is unknown if these audits can be indicators of management problems that impact animal wellbeing. The purpose of this literature review is to discuss current research about indicators of animal wellbeing on dairy farms.

In this review, the terms welfare and wellbeing will be interchangeable. Wellbeing is defined as "the state of being happy, healthy, or prosperous" (Merriam-Webster Online, 2012). Welfare is defined as "the state of doing well especially in respect to good fortune, happiness, well-being, or prosperity" (Merriam-Webster Online, 2012). According to the World Organisation for Animal Health animal welfare is defined as how an animal copes with the condition in which it lives (OIE, 2013). It is not possible to assess happiness and prosperity in animals and thus different methods of assessing wellbeing of farm animals are required (Table 1.2, Table 1.3). In 1979, the Farm Animal Welfare Council developed five freedoms in which all farm animals should have in order to ensure good welfare (Farm Animal Welfare Council, 1993). These freedoms include: 1) freedom from hunger, thirst and malnutrition, 2) freedom from discomfort, 3) freedom from pain, injury and disease, 4) freedom to express normal behavior, and 5) freedom from fear and distress. Freedom from hunger, thirst and malnutrition is accomplished by providing a diet that maintains health and vigor, as well as providing clean fresh water ad libitum. Freedom from discomfort is achieved by providing an appropriate living environment that includes shelter and a

comfortable resting area. Freedom from pain, injury and disease can be managed by prevention and rapid diagnosis and treatment of an injury or disease. Freedom to express normal behavior is accomplished by providing proper housing facilities with sufficient space and company of animals of its own species. Freedom from fear and distress can be achieved by providing conditions and treatment which avoid mental suffering.

1.1.1 Dairy farm management and its challenges

Historically in the United States there has not been a single defined standard for managing dairy cattle, thus each farmer has independently made important management decisions; although legal regulations are in place for the mistreatment of livestock. Management factors that can influence the wellbeing of dairy cattle include: calving environment, management of colostrum, separation of the dam from her calf, the use of pain management procedures, weaning, grazing, housing environment, nutrition, and livestock handling. These areas of management are the most challenging when it comes to maintaining acceptable standards of animal wellbeing. Further research is required to determine if there are consistent measureable consequences that can be used to indicate if farmers are providing optimal levels of animal wellbeing.

1.2 WELLBEING OF DAIRY CALVES

The future of a dairy herd begins with proper care and wellbeing of calves. Management areas previously identified to be of great importance include the calving environment, calf housing, colostral management, separation of calf from dam, use of potentially painful procedures, and weaning management (Vasseur et al., 2010).

1.2.1 Calving environment

Depending on the individual farm and its circumstances, the calving area may or may not be a defined location. Regardless of location, it should be a clean, dry and warm place where the dam is comfortable, so as not to increase the level of stress induced by parturition. The calving environment can also influence the health of the newborn calf (Vasseur et al., 2010). In a recent study, 115 dairy farms scattered throughout Quebec, Canada were surveyed about calf rearing practices (Vasseur et al., 2010). Of herds that were surveyed, 51.3% did not use calving pens and the cows primarily calved in tie-stalls. Of the herds that used calving pens, 52.8% also utilized the pens to house sick animals, thus creating a potential source for increased exposure to pathogens.

The environment in which cows calve and the provision of neonatal care can both have a long lasting impact on the health and wellbeing of calves (Vasseur et al., 2010). When neonatal calves are exposed to a poor environment (such as an environment that increases stress, decreases hygiene or decreases comfort) their risk of disease is increased (Vasseur et al., 2010). The most common diseases of newborn calves include: diarrhea and respiratory problems (Frank and Kaneene, 1993; Losinger et al., 1995; Svensson et al., 2003) and the risk of these diseases can be increased by exposure to a poor environment during the first few hours of life (Vasseur et al., 2010). Monitoring monthly incidence densities of calf diseases is one method that can be used to evaluate calf wellbeing (Frank and Kaneene, 1993; Svensson et al., 2003). Other than stillbirths, neonatal disease is the most common cause for mortality in calves (McGuirk, 2008). The occurrence of neonatal diseases has also been

associated with an older age at first calving and an increased risk of dystocia at first calving (Svensson et al., 2003).

1.2.2 Calf housing

In the United States, there are no uniform standards for housing dairy calves. However, the Canadian Dairy Code of Practice (National Farm Animal Care Council, 2009) specifies that housing must allow for calves to turn around, lie down, stand up, adopt normal resting postures and have visual contact with other calves. Housing should provide comfort, insulation, warmth, dryness and traction, bare concrete is unacceptable. When placed in group housing the area for resting must be large enough to allow all calves to rest comfortably at the same time.

1.2.3 Colostral management

Receiving sufficient colostrum is vital to a calf's health and wellbeing. Colostrum provides the unprotected neonate with immunoglobulins. For optimal absorption of sufficient immunoglobulins the newborn calf must receive between 10% to 15% of their body weight of colostrum at the first feeding (Godden, 2008). For smaller calves this would be a minimum of two liters, and for normal to larger calves this should be a minimum of four liters of high quality colostrum given by six hours of life (Weaver et al., 2000; Vasseur et al., 2010). When sufficient colostrum is not provided, mortality has been shown to dramatically increase (Wells et al., 1996; Godden, 2008). Calf mortality rates are thus one measurement that can be used to assess the adequacy of neonatal calf care (Wells et al., 1996). Colostrum can be provided in many ways, such as thru a bottle, a tube feeder or directly from the dam. Besser et al. (1991), conducted a study on Holstein calves from three different farms. The

authors reported a failure of passive transfer of immunoglobulins occurred in 61.4%, 19.3% and 10.8% of calves that received colostrum from nursing the dam, a nipple-bottle and a tube feeder, respectively. Another study conducted by Svensson et al. (2003), found that calves which nursed their dams for colostrum had a significantly higher risk of developing diarrhea compared to calves that received their colostrum from the farmer. In contrast, a study conducted on 96 Jersey calves found that calves which nursed the dam for colostrum had greater serum IgG and IgM concentrations at 24 hours compared to calves that received 2 liters of colostrum from a nipple-bottle (Quigley Iii et al., 1995). Although studies may contradict the appropriate method to feed colostrum, the concentration of immunoglobulins and the volume of colostrum received is far more important (Weaver et al., 2000).

1.2.4 Separation of the calf from the dam

Separation of calves from their dam is another potential welfare concern. There are disagreements regarding when the calf should be separated, with researchers arguing for both early separation (Windsor and Whittington, 2010) as well as later separation (European Food Safety Authority, 2006). Some researchers have reported that removal of calves before they are allowed to suckle decreases exposure to pathogens and allows for easier control over colostrum intake (Windsor and Whittington, 2010). In another study, later separation of calves from the dam was reported to account for 16% of mortality (Wells et al., 1996). The authors concluded that the longer the calf remained with the dam the odds of mortality increased (the odds of mortality was 3.2 for calves that remained with their dam > 24 hours vs. 1.1 for calves that remained with their dam < 24 hours). In contrast, a publication from the European Food Safety Authority (2006) states that early separation of calves results in a

decrease in maternal care and thus decreased calf welfare. Flower and Weary (2001) investigated the separation of dams and their calves at one day as compared to separation at two weeks after birth. The results of this study showed that (after separation) calves and cows in the late separation group vocalized more as well as placed their heads outside the pens more frequently as compared to animals in the early separation group. These behavioral responses are an indication of distress. However in this study, calves in the later separation groups gained weight, at a rate of about three times faster, and developed more social behaviors as compared to the calves in the early separation group. Further research may be necessary to determine the best time to separate the calf and dam.

1.2.5 Pain management procedures

The perception of pain during animal handling or management procedures is another controversial welfare issue. Molony and Kent (1997) defined pain as "an aversive sensory and emotional experience representing an awareness by the animal of damage or threat to the integrity of its tissues." Potentially painful procedures performed on dairy cattle may include: dehorning, castration, and removal of supernumerary teats. Dehorning is recommended to reduce the risk of injuries to farm workers as well as to other cattle (Faulkner and Weary, 2000). Anesthetics or analgesics can be administered to mitigate pain. Dehorning should be done prior to three months of age so that less painful techniques can be used (Faulkner and Weary, 2000). Hoe and Ruegg (2006) conducted a survey of 587 dairy producers distributed across Wisconsin. The purpose of the survey was to characterize the opinions and practices of dairy farmers about animal well-being and biosecurity. In this study, dehorning was believed to be at least a little painful by about 80% of the farmers

surveyed and 50% believed that dehorning may cause moderate to a lot of pain. However, only 18% of these farmers reported the use of local anesthetics to mitigate pain. Misch et al. (2007) conducted a similar study in Ontario, Canada using 207 producers and 65 veterinarians. In their study, 78% of the producers reported that they dehorned their own calves, but only 22% of producers reported the use of local anesthetics. Veterinarians reported that they dehorned about 31% of their client's calves and 92% reported the use of local anesthetics. Of all producers surveyed, 13% were unaware of options available for pain management.

Dehorning is a common practice, although different countries have different standards. For example, Sweden has banned dehorning of all ages of cattle unless local anesthetics and sedation are used (Bengtsson et al., 1996). In the United Kingdom, calves less than one week of age can be dehorned using caustic paste, but local anesthetics are required if any other method is used (Kent, 1999). In Canada, it is required that pain control be used for all disbudding and dehorning (Faulkner and Weary, 2000). Nonetheless, there are no standards for dehorning in the United States, and it is thus common for farmers to dehorn calves without the use of anesthetics or analgesics. This may be due to a lack of awareness of alternatives that can be used for relief of pain (Hoe and Ruegg, 2006).

Measurement of plasma cortisol is commonly used as an indicator of animal stress (Mostl and Palme, 2002). In one study, researchers enrolled 57 male Friesian calves, and divided them into 6 treatment groups for dehorning: control (n = 10), standard scoop (n = 10), saw (n = 10), guillotine shears (n = 10), embryotomy wire (n = 10), and adrenocorticotropic hormone (ACTH) injection (n = 7). The calves in the ACTH group were

injected with 40 mg to elicit a maximum cortisol response. Plasma cortisol was measured once prior to treatment and multiple times after dehorning. For all methods, a cortisol peak of 100 nmol/L was reached within 30 minutes after dehorning was performed and lasted for 30-60 additional minutes. The concentration of cortisol returned to pre-treatment levels by six hours after treatment (Sylvester et al., 1998). In a review, Stafford and Mellor (2005) reported that the cortisol response was considerably less when cautery disbudding was used as compared to amputation, and concluded that amputation is a more painful method. The authors concluded that use of a local anesthetic (such as lidocaine) 15-20 minutes prior to amputation would eliminate the cortisol response for the first two hours after dehorning. However, plasma cortisol concentrations were increased for about six additional hours. In contrast, they reported that when lidocaine was combined with cauterizing, the cortisol response was greatly reduced. An additional method reviewed was the use of an anesthetic and an analgesic (ketoprofen). When used together they virtually eliminated the cortisol response, including the plateau, as well as behavioral responses (Faulkner and Weary, 2000; Stafford and Mellor, 2005).

Recognition of pain in animals is difficult because animals are unable to verbalize their discomfort. Molony and Kent (1997) stated that "animal pain can be recognized and assessed using physiological and behavioral indices." Faulkner and Weary (2000), conducted a study using 20 Holstein calves to investigate behavioral responses associated with pain after dehorning. All calves received a sedative and a local anesthetic and were split into either a control group (n = 10) or a treatment group that received ketoprofen (n = 10). The sedative was given to eliminate the need for restraint during dehorning. Behavioral

responses were assessed by measuring the amount of head shaking, ear flicking, head rubbing and weight of each calf was measured on the day of treatment and the following two days. Calves treated with ketoprofen gained more weight during the first 24 hours after dehorning as compared to calves that received no treatment. Less head shaking and ear flicking were observed in calves treated with ketoprofen as compared to calves in the control group. There are many common ways in which to measure pain including serum cortisol levels and behavioral responses. Some additional but, less common methods to measure pain include the measurement of substance P (Coetzee et al., 2008), and the use of infrared thermography (Stewart, 2008). Substance P is a protein neurotransmitter, which functions to cause pain. This protein is measured in plasma and remains in the animal's system longer and at a greater amount than cortisol, which can diminish quickly after a stressor occurs (Coetzee et al., 2008). Uses of serum cortisol levels alone to measure pain may be debatable because it is only able to represent the hormonal response of animal distress, as cortisol is an indicator of the HPA axis being activated (Mellor and Stafford, 1997). Observation of changed behavior is considered to be a good indicator of the duration and phases of pain (Stafford and Mellor, 2005). Further research may be necessary to determine a more reliable method for measuring pain and the least painful method for potentially painful management procedures such as dehorning.

1.2.6 Weaning management

Weaning is the first potentially stressful feeding transition for young calves (Weary et al., 2008; Vasseur et al., 2010). To avoid decreased feed intake, weight loss and excessive

vocalization, weaning should be gradual and based on the animal's ability to eat solid food (Jasper et al., 2008; Weary et al., 2008; Vasseur et al., 2010). The process of weaning calves can be either gradual or abrupt. Gradual weaning is a process in which a slower transition takes place and is accomplished after the calf is eating a certain amount of solid food. Abrupt weaning is accomplished by immediate removal of milk from the diet. Jasper et al. (2008) studied the immediate behavioral responses of 30 dairy calves that were weaned both gradually and abruptly from milk. Milk was removed from all calves but one group was given warm water in place of milk as to provide a soothing apparatus (using the same routine that had been used to feed milk). The calves that did not receive warm water represented abrupt weaning without a soothing apparatus, whereas the group of calves who received the warm water represented slow weaning with a soothing apparatus. Trained observers recorded the number of vocal calls, movements, oral contacts, as well as the amount of times the calf's head was out of the pen. In this study, calves that were weaned abruptly showed a greater amount of behavioral responses as compared to calves that were gradually weaned. The number of vocalizations was significantly less for the calves provided with warm water ($P < 0.001$). Activity and time that the calves spent with their heads out of the pens were also less for the gradually weaned group ($P < 0.005$). This study demonstrated that weaning methods can result in signs of distress (such as increased vocalization) as well as increased activity. Thus it is very clear that weaning procedures can adversely affect calf wellbeing.

1.3 DAIRY COW WELLBEING

Consumer trust is vital to maintaining the prosperity of the dairy industry. Public attention about cow wellbeing has been directed toward the following areas: animal health

(Hovi et al., 2003), prevalence of lameness (Blackie et al., 2011), handling of non-ambulatory cows (Stull et al., 2007), stockmanship (Hemsworth et al., 1995), and the impact of housing on cow health (Barberg et al., 2007). Welfare of cows can also be reduced by malnutrition, injury, disease, tail docking and handling of downer cows (Tucker et al., 2001; Schreiner and Ruegg, 2002; Stull et al., 2007; Roche et al., 2009). All of these areas are of importance and can impact the wellbeing of animals. In response to consumer concerns the dairy industry has begun to address these issues by educational programs, welfare audits, welfare assessments and the development of uniform standards for animal care.

1.3.1 Housing

Assuring wellbeing of cattle is the overall goal when designing and managing dairy cattle facilities used for housing and milking of dairy cows. Characteristics of good housing should allow for maximum comfort such as, adequate stall design (size and neck rail position) (Haley et al., 2000; Lombard et al., 2010), and adequate bedding (clean, dry, and sufficient amounts) (Lombard et al., 2010). When housing is not designed correctly or properly maintained, cows may become injured and develop lameness (Rushen, 2001), develop hock lesions (Regula et al., 2004; Rutherford et al., 2008), exhibit abnormal behaviors (Haley et al., 2000; Blackie et al., 2011), experience teat injuries (Regula et al., 2004) or become dirty (Regula et al., 2004).

1.3.2 Pasture

The perception of many consumers is that happy, healthy cows must reside on lush green pasture. The “Happy Cows Come from California” commercial created by the California Milk Advisory Board (2011) is one example of this portrayal. Pasture allows for

grazing which is a natural feeding behavior of ruminant animals and may be associated with decreased lameness (Richert, 2012). A current study involving 292 organic and similarly sized conventional dairy farms across New York, Oregon, and Wisconsin reported that both organic and conventional farms that grazed (cows received > 30% dry matter intake from pasture) were more likely to house lactating cows on pasture for primary housing. An increased prevalence of cows scored lame was found to be associated with conventional non-grazing herds as compared to conventional grazing herds and organic herds (Richert, 2012). A recent study using 72 cows (split into 18 groups; 4 cows per group) either assigned to stay on pasture or in a freestall barn for four weeks were observed for gait scores and specific gait attributes (back arch, head bob, tracking up and reluctance to bear weight) using a standardized method created by Flower and Weary (2006). The authors reported that lame cows (gait score > 3) that were placed on pasture showed improvement in locomotion score of 0.22 units per week (Hernandez-Mendo et al., 2007).

Krohn (1994) conducted a study to measure grooming behaviors, abnormal behaviors (bar-biting and leaning against equipment) and exploration behaviors of cows housed in both an extensive environment (loose housing/pasture; n = 12 cows) and an intensive environment (tie stalls; n = 12 cows). The cows were divided into four groups: 1) loose housing and continuous access to pasture, 2) tie stall housing with concrete flooring covered with a limited amount of straw (no exercise), 3) tie stall housing with rubber mats and two kg of straw (no exercise), and 4) tie stall housing with rubber mats and two kg of straw (with one hour of daily exercise). Cows that had daily exercise demonstrated increased frequencies of social behavior, self-grooming and investigative behavior with decreased bar-biting as

compared to the animals not allowed to exercise. The authors concluded that daily exercise allows cattle to perform natural behaviors and positively impacted the wellbeing of cows by decreasing deprivation. Although the use of pasture has an impact on the well-being of dairy cattle, access to pasture is not always feasible for all producers. For this reason, further research should examine the provision of a rest period on pasture for cow welfare.

1.3.3 Lameness

Lameness is a concern of many dairy producers as it negatively impacts both productivity and animal wellbeing (Thomsen et al., 2008). Several methods have been developed to evaluate locomotion of dairy cattle (Table 1.4). Most scales range from 1 to 5 with 1 indicating normal locomotion and 5 indicating that the cow is severely lame. Observations of movement (as well as body indicators) may be used along with locomotion to score lameness. Body indicators that are used include reluctance to bear weight on specific limbs, changes in head movement and abnormal back posture.

A survey conducted by National Animal Health Monitoring System (2007) represented 82.5% of dairy cows in the United States across 17 of the nation's major dairy states. In the survey farmers reported that 14% of cows were classified as lame and 20% of adult cow mortality was related to lameness. Lameness is known to be associated with housing (Haskell et al., 2006), nutrition (Barker et al., 2007), the amount and quality of bedding used (Barker et al., 2007; Fregonesi et al., 2007), overcrowding of cattle (Cook and Nordlund, 2009), walkway conditions and handling of livestock (Hemsworth et al., 1995).

Sprecher et al. (1997) developed a 5-point scale for assessing locomotion (Table 1.4) and tested whether the assessment could predict future reproductive performance and the risk

of culling on 66 cows in a single dairy herd. The lameness scoring system developed effectively categorized cows into normal or mildly lame versus moderately to severely lame. Cows with a lameness score > 2 (n = 43; 65.2%) were also predicted to have prolonged time intervals between calving and conception. Barberg et al. (2007) conducted a study in Minnesota to develop descriptive data about bedded pack dairy barns. Data was collected about management practices, cow welfare, herd performance, udder health and producer satisfaction, both prior to and following the change in housing system. They studied cows housed in 12 compost barns representing 92% of all dairies in Minnesota that used bedded pack dairy barns for at least 6 months. The average herd contained of 73 +/- 35.5 cows. The researcher concluded that 7.8% of all cows were clinically lame (locomotion score ≥ 3 on a scale of 1 to 5 (Sprecher et al., 1997)) and the prevalence of lameness for individual herds ranged from 0 to 22.4%. The herd with the greatest prevalence had still been recovering from chronic lameness due to previous housing. The authors concluded that the main goals such as improving cow comfort, health and longevity for the use of compost bedded pack housing were attained. Flower and Weary (2006) used a 5 point locomotion score (1 = sound and 5 = severely lame), to investigate how hoof pathologies affected locomotion. The study enrolled cows with sole hemorrhages (n = 14), sole ulcers (n = 7), or no visible injuries (n = 17). Six specific gait attributes were collected along with the locomotion scores. The six gait attributes included: back arch, head bob, tracking-up, joint flexion, asymmetric gait, and reluctance to bare weight. Gait scores were reported as 4.0 and 3.1 for cows affected by sole ulcers and healthy cows, respectively. The authors concluded that the use of a numerical scoring system and an analog visual scoring system correctly identified cows with sole

ulcers. Blackie et al. (2011) examined the impact of chronic lameness on lying behavior by scoring 59 dairy cows located in a single dairy farm in the United Kingdom. Cows (n = 58) were classified into 3 groups based on maintaining a consistent locomotion score for 3 consecutive months. As compared to cows with a locomotion score of 1, cows with a locomotion score ≥ 3 spent significantly more time lying down and less time standing. The lying times were greater in the evening for lame cows and that their behavior was modified throughout the day, potentially to avoid conflict. The authors concluded that lying times in conjunction with other measure could detect lameness in dairy cattle. Haskell et al. (2006) assessed the effects of grazing, milk production, and type of housing system on the prevalence of lameness and leg injuries using 2,724 cows located in 37 commercial dairy farms in Great Britain. All cows were scored for locomotion using a scale of 1-5 (1 = sound; 2 = slightly uneven gait; 3 = lame; 4 = very lame; and 5 = extremely lame). The prevalence of lameness was greater for cows not grazed (39%) versus cows that were grazed (15%). Lameness negatively impacts the welfare of dairy cattle and therefore it is vital for farmers to recognize and treat cases of lameness.

1.3.4 Hock Lesions

Hock lesions can be considered an injury and are a direct result of friction between the cows' hock and the lying surface. The amount of hock damage directly reflects the amount of discomfort that is associated with the bedding surface provided for the cow (Rutherford et al., 2008). Both dichotomous (the presence or absence of hock swelling) (Zurbrigg et al., 2005; Rutherford et al., 2008) and categorical scoring systems have been developed to assess hock condition (Krebs et al., 2001; Regula et al., 2004). Krebs et al.,

2001 developed a 4 point scale for measuring hock condition (0 signifying no alteration; 1 signifying hairless, but skin unaltered; 2 signifying reddening and/or swelling of skin and 3 signifying an open wound or abscess).

Regula et al., 2004, used the scale developed by Krebs et al., (2001) to measure hock injuries for cattle housed using three different management systems: 1) tie stalls with minimal outdoor exercise (n = 458 cows in 31 herds), 2) tie stalls with regular outdoor exercise (n = 818 cows in 47 herds) and 3) loose-housing systems with regular outdoor exercise (n = 1025 cows in 46 herds). Cows that had minimal access to the outdoors had the greatest prevalence of hock injuries (21%) compared to cows in tie stalls with regular access to outdoors (16%), and cows housed in loose-housing with regular access to outdoors (13%). Norring et al. (2008) developed a 6 point scale for hocks ranging from 0 to 5, (0 = no lesion; 1 = some hair loss or broken hairs; 2 = bare skin visible with alopecia; 3 = thickening of the skin (calluses); 4 = reddening of skin; 5 = open cuts) and used the system to evaluate hock lesions on 52 cows at a single university farm, in Canada. In this study the effects of sand and straw bedding on resting time, cleanliness, hoof health, and hock injuries were measured. Hock scores for cows that were housed using sand bedding were less severe than hock scores for cows that were housed using straw (with lesion severity of 0.5 vs. 1 respectively, $P < 0.001$).

1.3.5 Lying Behavior

When housing does not meet the behavioral needs of cows, abnormal standing and lying times are often observed (Galindo and Broom, 2000; Haley et al., 2000; Blackie et al., 2011). Lying time is defined as the amount of time a cow spends in a recumbent position

and is important to production and welfare of dairy cows (Haley et al., 2000; Blackie et al., 2011). Blackie et al, (2011), monitored lying times of cows that were either lame (locomotion score ≥ 3) or healthy (locomotion score 1 & 2). Cows that were lame spent 13 hours per day lying down as compared to 10 hours per day for healthy cows (P = 0.01). More time spent lying down by lame cows could adversely affect their feed intake. Hassall et al. (1993) studied the differences between lame cows and normal cows during the summer using 60 cows from 3 commercial herds in England. The authors discovered lame cows spent more time lying down, less time eating, entered the parlor later, and were more restless while being milked as compared to healthy cows (P < 0.01). The more time spent lying suggested that the lame cows needed to alleviate pain. Haley et al. (2000) measured frequency and duration of standing and lying using 8 cows from a single herd. Total duration was defined as the total amount of time performing each behavior and bout duration was defined as the amount of time cows spent either standing or lying before changing their activity. The mean time spent lying was 14.7 hours per day for cows in large pens versus 10.5 hours per day for cows in tie stalls. However, average bout duration for lying was 68.0 minutes for cows in large pens versus 86.7 minutes for cows in tie stalls. The shorter time spent lying for cows in tie stalls may have been a result of an uncomfortable lying surface. The researchers concluded that a poorly designed stall could substantially reduce the amount of time cows spend resting. Norring et al. (2008) investigated the impact of straw versus sand bedding on the lying times and conducted a preference test for the two bedding types of 52 cows in a single herd. The total amount of time spent lying was significantly more (749 minutes) for cows bedded with straw versus cows bedded on sand (678 min, P = 0.001). On

the first day of the preference test cows kept on sand preferred to lie on straw, however by the third day the preference was no longer statistically significant ($P \geq 0.05$). The authors concluded that the correlations between lying time and hoof health were too complex to interpret lying time alone as a measure of the effect of stall design on animal welfare.

1.3.6 Teat Injuries

The design of animal housing areas can also influence teat injuries. Teat injuries are more common in tie stall barns probably due to smaller stall size (Bewley et al., 2001). Teat injuries can be assessed by visually examining the teats (Regula et al., 2004). In this study they concluded the prevalence of teat injuries were 1.6% (n = 676 cows on 40 farms) for cows housed in tie stalls that allowed for minimal outdoor access, 0% (n = 713 cows on 40 farms) for cows housed in tie stalls that had regular outdoor access, and 0.2% (1042 cows on 45 farms) for cows housed in loose housing that had regular outdoor access. Outdoor access was beneficial for cows kept in tie-stalls and resulted in a decreased prevalence of teat injuries.

1.3.7 Hygiene

Hygiene can impact dairy cattle wellbeing as it is associated with disease (Schreiner and Ruegg, 2003). Sant'Anna and da Costa (2011) defined corporal hygiene as an indicator of welfare of dairy cows and commented that hygiene is dependent on facilities, climatic conditions, and animal behavior. Numerous scoring systems have been used to assess dairy cattle cleanliness as well as its relation to disease (Table 1.5). Most scoring systems are based on either a scale from 1 to 5 (1 indicating clean and 5 indicating very dirty) or a scale from 1 to 4 (1 indicating clean and 4 indicating very dirty). Various body areas are scored

including: the cow's udder, belly, flanks, hind legs, and tail. Schreiner and Ruegg (2003) conducted a study using 1,250 lactating dairy cows on 8 commercial dairy farms to determine the relationship between udder and leg hygiene scores and measures of subclinical mastitis. A 4 point scale (1: completely free of or has very little dirt; 2: slightly dirty; 3: mostly covered in dirt; and 4: completely covered caked on dirt) was used to score hygiene of udders and legs. They concluded based on the 4-point scale the mean hygiene scores were 2.09 for udders and 2.33 for legs and that there was an association between dirty udders (scores 3 & 4) and occurrence of subclinical mastitis. Norring et al. (2008) compared the effects of straw versus sand bedding on lying time, cleanliness, hock injuries, and hoof health on 52 cows on a single farm. A scoring method was used to measure cleanliness by looking at ten different areas of the cow including: the teats, udder, belly, sides of the belly and legs. Each area was assigned 1 point if there was any dirt or manure visible allowing for a maximum score of 10. In this study cows that used stalls bedded with straw were dirtier (6.04) as compared to cows that used stalls bedded with sand (4.19). Although the cows in this study preferred to lie in straw bedded stalls, overall cleanliness was better for cows that had sand bedded stalls. Reneau et al. (2005) developed a simple system for scoring hygiene in dairy cattle and studied the ease and repeatability of the scoring system and association with individual cow somatic cell scores (SCS's). Of the 1,191 cows, 98 cows were located on the University of Minnesota-Saint Paul dairy farm and 1,093 cows were located across 8 farms in Minnesota. The hygiene score developed was a 5 point scaling ranging from 1-5 (1: the area was very clean and 5: the area was very dirty) and looked at five different body areas including: the tail head, thigh, abdomen, udder and hind limbs. To examine the repeatability

and ease of use of the hygiene score, four experienced evaluators scored 75 cows and fourteen college students compared their scores of 23 cows to two faculty members. The mean correlation coefficients for the experienced evaluators were ≥ 0.884 and the mean correlation coefficient for the students and faculty members was 0.804 indicating high repeatability. To determine the correlation between individual cow SCS and hygiene a single observer scored 1,093 cows. Out of the 5 areas scored only two were statistically associated with individual SCS's. The two areas were udder ($P = 0.03$) and hind limbs ($P < 0.01$). The authors concluded that the hygiene scoring system was easy to use and repeatable and that only hygiene scores for the udder and hind limbs were significantly associated with SCS. Fregonesi and Leaver (2001), conducted two experiments to determine comparative indicators of welfare in the two most common loose-housing systems (strawyards and cubicles) on 24 cows at the Wye College Dairy Research Unit, London. The cows were assessed for cleanliness using a 6 point scale ranging from 0-5 (0: clean udder, belly rear legs and tail, 1: clean udder, belly, rear legs or tail with very minimal dirtiness, 2: minimal dirt on the udder, and some dirt on the belly, rear legs or tail, 3: some dirt on the udder, and the belly, rear legs or tail with dirt, 4: all areas dirty, and 5: all areas very dirty). For both experiments cows housed in cubicles were significantly cleaner than cows housed in strawyards ($P < 0.001$).

Researchers have concluded that cleanliness can be a measure of risk factors such as housing, bedding material and fecal consistency in dairy cattle. Several studies have demonstrated that dirty cows are at greater risk for developing disease, such as mastitis and decreasing welfare (Table 1.5).

1.3.8 Potentially painful procedures for adult cattle

Tail docking is a procedure performed on adult dairy cattle to aid in cow cleanliness, and milking personnel comfort (Stull et al., 2002). Tucker et al. (2001) studied whether tail docking would influence cow cleanliness and udder health on 169 docked and 105 undocked cows on a single farm in British Columbia. Cleanliness was measured by placing a 5 X 17.5 cm wire grid with 14 equal squares on each cow's back and rump. Each square that contained debris was counted (0-14) and a severity of soiling in each grid area was scored on a scale of 0 to 3 (0 equaled no debris, 1 equaled flecks of debris, 2 equaled a film or thicker chunks of debris, and 3 equaled thick caking of debris). Udder cleanliness was then assessed in the parlor at week 2 and 4 after docking, the scores used included: the number of teats with debris and the same score of 0-3 on the udder itself. Udder health was also measured as the number of cows that developed mastitis as discovered by the veterinarian and by somatic cell count (SCC) from two milk samples. The authors concluded that there was no significant difference between the two groups (docked and undocked) for the number of squares containing debris, the severity scores of debris in each area and in either udder cleanliness or SCC. Stull et al. (2002) reviewed scientific literature for tail docking and concluded that tail docking can be detrimental especially when high fly densities exist and no data is available supporting the claims that tail docking improves worker's comfort or safety. The author concluded that there is sufficient evidence to support their hypothesis that there is no benefit to tail docking in dairy cattle.

1.3.9 Nutritional management and animal wellbeing

Provision of adequate diets are vital for maintaining dairy cattle health and productivity (Burkholder, 2000). Researchers have studied different scales and methods (i.e. visual and/or palpation) in which to measure the proportion of body fat (Table 1.6). One way to assess energy balance of cattle to visually assign a body condition score (Table 1.6). Scales used to measure body condition of dairy cattle include: a 4 point scale (Roche et al., 2009), a 5 point scale (Barberg et al., 2007), a 8 point scale and a 10 point scale (Berry et al., 2007). Some scales may also include increments of 0.5 and 0.25, such as a 5 point scale with 0.25 increments developed by Edmonson et al. (1989). In all instances the lowest number indicates extremely thin (under conditioned) and the greatest number indicates extremely overweight (over conditioned). Several body areas of dairy cattle are analyzed including: the loin, pelvis, tail head, lumbar vertebrae, thoracic, ribs, hip bones, pin bones, and the thigh region (Table 1.6). When cattle are not provided appropriate energy for their stage of lactation they may become either over-conditioned or under-conditioned. Over-conditioning and under-conditioning at calving are both detrimental and can result in decreased milk production, reduced conception rates, and reduced immune function (Roche et al., 2009). Cows that are over-conditioned have an increased risk of metabolic disorders and cows that are under-conditioned may have a decreased comfort in cold environments (Roche et al., 2009). Roche et al. (2004) examined the relationships among different body condition scoring systems. A total of 154 cows from the United States, 110 cows from Australia and 120 cows from Ireland were used to assess each differing body score system. Each country assessed body condition using different methods as well as different scales. In New Zealand

and Ireland, trained personnel assessed body condition by palpation and visual assessment of body parts, whereas in Australia and the United States, trained observers scored body condition using only visual assessment. For the differing scales, (for all scales, low values = emaciation, high values = obesity) a 5-point scale was used in the United States and Ireland (Wildman et al., 1982; Edmonson et al., 1989) compared to an 8-point scale used in Australia (Earle, 1976) and a 10-point scale use in New Zealand (Macdonald and Macmillan, 1993; Macdonald and Roche, 2004). In this study there was a strong positive linear relationship ($P < 0.001$) between the New Zealand 10-point scale and all the other scoring systems including: the United States (5-point scale, $r^2 = 0.54$), Ireland (5-point scale, $r^2 = 0.72$), and Australia (8-point scale, $r^2 = 0.61$). Berry et al. (2007) studied the effect of periparturient body condition and body weight related traits on the incidence of dystocia and stillbirths using 879 cows located on a research farm in New Zealand. Body condition was assessed by palpating individual body parts based on a 10 point scale (Roche et al., 2004). The authors concluded that no apparent interactions between body condition and body weight on the incidence of dystocia were observed. Ferguson et al. (1994) assessed the ability of four observers to independently assess body condition. The observers used a five point scale with 0.25 increments and described several body regions on 225 cows from a 400-cow commercial dairy. The body regions described included: the spinous and transverse processes of the lumbar vertebrae, the hook bone, pin bone, ileo-sacral and ischio-coccygeal ligaments, the tail head and the thurl region. Body condition scores ranged from 1.5 to 4.5, with a mean of 3.21. The mean BCS was no different for observers 1, 2 and 3, however, was statistically lower for observer 4 ($P < 0.05$). The authors concluded that the observers agree

58 to 67% of the time when independently scoring cattle and 21 to 34% of the time they only differ by +/- 0.25 units. Waltner et al. (1993) conducted a study on 350 dairy cows at Washington State University to determine what relationships existed between body condition scores and production variable in high producing dairy cattle. Cows were assessed body condition on a five point scale developed by Wildman et al. (1982) at monthly intervals for 24 months. The authors concluded that loss of body condition increased with increasing parity (0.3 first lactation and 0.9 $\geq$ 4 lactations) and there were no significant relations between body condition scores and the incidences of metritis, pyometra, retained placenta, cystic ovarian disease, number of artificial inseminations per conception, days to first insemination and dystocia. Since welfare can be reduced by malnutrition it is imperative that animal care givers have the ability to physically measure fat reserves.

1.3.10 Involuntary Culling and Mortality

Both involuntary culling and mortality can reflect poor welfare of dairy cattle (Thomsen and Houe, 2006; Ahlman et al., 2011). Involuntary culling is defined as a cow that leaves the heard due to health, disease or decreased reproductive performance in contrast to voluntary culling when a cow leaves the herd by choice (usually because a replacement is available), (Hoeck and Kluth, 2000). A simple way to measure culling and mortality are through rates (number of dead cows per 100 cow years) and risks (number of dead cows per 100 lactations) (Houe et al., 2004). In the United States, 23% of cows were culled from their herd for reasons other than death (USDA, 2007). Of these animals 26.3% were culled for reproductive problems, 23% were culled for mastitis or udder problems, 16.1% were culled for poor production and 16% were culled due to lameness or injury. The percent of deaths

were 7.8, 1.8, and 5.7 for unweaned heifers, weaned heifers, and cows, respectively. Over half of the deaths for unweaned heifers were due to scours or digestive problems and almost a quarter were due to respiratory problems. For the weaned heifers 46.5% of mortality was due to respiratory problems. Lameness and injury (20%), mastitis (16.5%), calving problems (15.2), and unknown causes (15%) caused mortality to dairy cows. A review by Thomsen and Houe (2006) discussed risk factors associated with mortality from research conducted on intensive dairy operations. They found that mortality ranged from 1-5%, and indicated that this range was subject to large variation. Statistically significant risk factors included: age (>3 lactations), a great amount of purchased livestock and increasing average somatic cell count. The authors concluded that mortality is not only a problem for welfare, but can also cause a financial burden. Welfare can be compromised due to suffering before death or euthanasia.

1.4 LIVESTOCK HANDLING

Freedom from fear is one of the five freedoms and an important aspect of animal welfare (Bertenshaw et al., 2008). When dairy cattle are mishandled severe consequences may occur, including induced fear, increased stress and injury (Hemsworth et al., 1989; Hemsworth et al., 1995). Flight distance is a measure for how close a person is able to get to an animal before it moves away and is used as a measure of fear of humans (Uetake et al., 2002; Main et al., 2003). The effect of poor handling can also be measured by assessing heart rate or cortisol levels (Hemsworth et al., 1989; Hopster and Blokhuis, 1994; Hemsworth et al., 1995). Heart rate is one measurable indicator of a stressful event or an environmental challenge (Hopster and Blokhuis, 1994), however, can be difficult to monitor

for animals not handled frequently since the method of measuring requires that a strap is placed around the animals girth. Cortisol can be measured using blood serum, but the collection of blood is an invasive procedure and may alter the results. A more accurate way to measure cortisol levels is thru the measurement of fecal glucocorticoid metabolites (Morrow et al., 2002; Mostl and Palme, 2002). To measure fecal glucocorticoids is non-invasive, but does require the right amount of time to be passed through the animals system after the stressor occurs. Hemsworth et al. (1989) studied the effects of human interaction at parturition and during milking on cow behavior, milk cortisol levels and heart rate during milking. In this study, 14 cows from a single herd were randomly assigned to either a non-handled group (n = 7) or a handled group (n = 7). The cattle in the non-handled group were only observed at calving and human contact was minimal, whereas the handled group were observed as well as handled for the first hour after calving. Cattle in the non-handled group showed more behavioral responses (such as flinching, stepping and kicking) for the first 20 weeks of lactation as compared to the cows that were handled ($P < 0.05$). Cortisol levels were significantly higher for the non-handled group (0.98 ng ml^{-1}) as compared to cows in the handled group (0.86 ng ml^{-1}, $P < 0.05$). There was no difference in the mean heart rate based on handling. Animals that have frequent contact with people tend to be less stressed when being handled or restrained compared to animals without frequent contact (Grandin, 1997). Inducing stress due to improper handling (yelling, pushing, hitting, etc.) negatively impacts animal wellbeing (Munksgaard et al., 1997). Proper training of employee's should be mandatory and recurrent on dairy farms.

1.5 WELFARE AUDITS AND ASSESSMENTS

Welfare audits are an external validation with regulatory compliance and are based on a pass or fail system without providing education for improvement. Whereas, welfare Assessments are co-operative effort with self-assessment possible either by external or internal validation and the goal for assessments is to improve the dairies score through training and awareness. Dairy animal welfare audits and assessments are designed to assure the consumer that their food comes from animals that have been treated properly (Reynolds, 2006). One example of welfare critical control points for dairies was outlined by Grandin (2011). In this outline animal based measures include: body condition scores, lameness scores, hygiene scores, leg lesion scores and falling and vocalization during handling. These critical control points also highlight the following activities that should be prohibited: dragging downed non-ambulatory cows, using unapproved methods of euthanasia, beating animals, depriving calves of colostrum, unapproved surgical procedures.

There are several assessment and audit systems currently utilized in the United States (Table 1.1). Each program is individual; but with some similar and some unique specific areas of importance. Farmers who complete the certification process can utilize the program's seal to market their dairy products. In order to become certified the farm must meet the individual program's standards and be audited annually. One audit program is the American Humane Association (2012) standards include areas of importance such as: office records, management, on-site food and water, on-site environment and transportation. Included in The American Humane Association standards are measurements such as: body condition, slips and falls, lameness and locomotion, hygiene, leg condition, udder condition

and coat condition. An assessment program is the Animal Welfare Approved (2012), which provides standards to ensure social interaction, comfort and overall wellbeing. Important areas of concern include: ownership and operation, breeds and origin of animals, health management, separation, euthanasia, emergencies, animal management, food, water, pasture access, housing and shelter, removal of animals from approved location, protection from predators, control of rodents, record keeping, handling, transportation, slaughter, and program management. There are no physical measures such as body condition, locomotion, hygiene or hock condition included in these standards. The program Humane Farm Animal Care (2012) areas of importance include: food, water, environment, management, herd health, transportation, processing, and slaughter. This program also includes measures for body condition and locomotion. The Food Alliance (2003) is one of the oldest programs from dairy welfare. This program specifically prohibits the use of feed additives, sub-therapeutic antibiotic usage, hormone treatments, and genetically modified livestock (including embryo transfers). In addition to the prohibitions critical areas provided include: nutrition, health, living conditions, transportation, cattle handling, handling facilities, slaughter, food safety and bio-security, management, feed production, land management, feed storage, manure management, and animal pest management. This program does not include physical measures but, measures the percentage of confined animals and the percentage of feed purchased. The National Dairy Animal Well-Being initiative was developed by National Dairy Farm Program (2012) to promote consistent principles and guidelines for dairy animal well-being. In this initiative important areas of concern include: nutrition, animal health, management, housing and facilities, handling, movement and

transportation. These programs provide a great resource for dairy farmers on management decisions. However, the programs that included inspection checklists did not provide additional information or resources on how to improve animal welfare. In addition, not all programs are created equal and there is no scientific evidence proving one standard better than the other (Table 1.1). More research is required to define specific standards including biological measures to perform and certify a farm welfare audit.

1.6 CONCLUSION

There are many biological measures that can be used to indicate management decisions on dairy farms. Animal wellbeing is beneficial to the dairy industry, because when animals are well cared for they have less disease and are more productive. Thus, change is crucial to develop an easy way to measure the consequences of poor management that affect the animal's wellbeing. Unfortunately just measuring these consequences, does not necessarily indicate where the problem lies. A single consequence may reflect multiple problematic areas. This is why each measure needs to relate back to the individual practice of concern.

The objective of this thesis is to determine indices of animal wellbeing and to identify management decisions that reflect positive wellbeing. It is important to not only measure these consequences that occur, but to also be able to relate them back to a management practice that can be fixed or modified to improve wellbeing for each individual farm.

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Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
American Humane Association (Farm Animal Program) (2012)	The American Humane Association Farm Animal Program is a dairy cattle welfare program in which farmers can become certified and use the program's seal to market their dairy products. In order to become certified the farmer must meet the standards and participate in an on farm audit annually.	1. Office records and management including: company policy, employee code of conduct, office records, documentation, nutrition, plans for lighting, animal health plans, bio-security and sanitation, SOPs for calves, weaning, handling, care & handling of sick or injured animals, records of stockperson training, inspections of livestock, inspections and maintenance of equipment, SOPs for husbandry and other procedures, and euthanasia policy 2. On-site food and water 3. On-site environment including: buildings, auxiliary power and alarm systems, thermal environment & ventilation in indoor facilities, lighting in indoor facilities, lying area, space allowances, freestall housing, access to turnout lots/ pasture, additional housing requirements, calving environment, calf hutches, bull pens, handling and treatment facilities, wind breaks, sun shade and sprinklers, auditor evaluations of livestock, milking barn or parlor, and state and federal milk requirements	Scored and recorded by trained farm personnel as well as measured by auditor A. Body condition scores B. Slips and falls C. Lameness/locomotion scores D. Hygiene scores E. Leg condition scores F. Udder condition scores G. Coat condition scores

Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
		4. Transport including: transport SOPs, loading and transport of animals, slaughter	
Animal Welfare Approved (2012)	A voluntary program in which farmer's receive a minimum of one visit per year to confirm compliance with the standards. The provisions ensure social interaction, comfort and physical and psychological well-being.	1. Ownership and operation 2. Breeds and origin of animals including: the dairy breeding herd 3. Health management including: dairy cows, temporary separation and euthanasia 4. Emergencies 5. Animal management including: dairy cows and calves, provisions for calves, weaning and separation, castration, physical alteration of dairy cattle and identification 6. Food and water 7. Pasture access including: pasture for dairy cattle and calves, and exclusion from pasture 8. Housing and shelter including: dairy cattle and calves, male breeding animals and bedding 9. Removal of animal from the approved farm including: routine use of land that is not controlled by the approved farm and temporary removal of approved animals from approved farm	No physical measurements are mentioned in approved standards

Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
		10. Protection from predators and control of rats and mice 11. Records and record-keeping 12. Handling 13. Transportation including: dairy cattle, calves and sale of animals before slaughter 14. Slaughter 15. Program management including: derogations	
Humane Farm Animal Care (2012) (Certified Humane)	A program to certify farms that adhere to their standards. Farmers are allowed to use the logo after completion of application and inspection by Humane Farm Animal Care. Inspections are annual and cost of becoming certified covers inspection cost and promotion of logo.	1. Food and water including: feed, food specific provisions for calves and water 2. Environment including: building, thermal environment and ventilation, aerial contaminants, lying area and space allowances, housing for cattle, specific provisions for calves, lighting, calving environment, milking parlor, bull pens and handling facilities 3. Management including: managers, handling, identification, equipment, inspections, and farm dogs 4. Herd health including: health care practices and casualty 5. Transportation 6. Processing	These scores are listed in the animal care guide A. Body condition score B. Locomotion score

Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
		7. Slaughter	
Food Alliance (2003)	A voluntary certification program that provides food and agriculture industry with sustainable standards, evaluation tools and a third party certification. This program prohibits the use of feed additives or sub-therapeutic antibiotic usage (milk cows treated with antibiotics must be separated), hormone treatments, and genetically modified livestock (including embryo transfers). Not only must the farm meet these standards, but the operation must meet a score 3 out of 4 in each of the two areas listed in the "areas of importance".	1. Product specific evaluation criteria for health and humane care of livestock includes: nutrition, health, living conditions, transportation, cattle handling, handling facilities, slaughter, food safety and bio-security 2. Other product specific evaluation criteria includes: Dairy management and systems (lactations, milk quality, confinement, feed source, water usage, milk waste, & structure drainage), feed production and land management (confinement areas and riparian zones), feed storage (fertilizer usage, crop/pasture insect pest, crop/pasture disease, weed management and herbicide usage), manure management (manure management plan, storage, manure and fertilizer applications and application equipment), and animal pest management (flies, external parasites, internal parasites and rodents)	Measurements are recorded by auditor A. Percent of animals confined B. Percent of feed purchased

Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
National Dairy FARM (farmers assuring responsible management) program (2010)	This voluntary program was created by the National Milk Producers Federation (NMPF), with help from the Dairy Management, Inc. (DMI) in order to show farmers commitment to providing the highest standards for animal care and quality. In order to be certified farmers must establish an on-farm animal wellbeing program and have third-party verification.	1. Management, standard operating procedures (SPOs), training and record keeping including: veterinary/ client/ patient relationships, training, sops, emergency planning, identification, record keeping and milking routine 2. New born calves including: nutrition, animal health, environment and facilities, handling, movement and transportation 3. Nutrition including: water, feed specific life cycle considerations 4. Animal health including: herd health plan, animal monitoring, sanitation, locomotion, body condition scores, hock lesions, and specific life cycle considerations 5. Environment and facilities including: animal environment, temperature, air quality, lighting, noise, stray voltage, facilities, stanchion/ tie stalls, freestalls, open lots/pastures, floor space, bedding, flooring, social environment, management of facilities and specific life cycle considerations 6. Handling, movement and transportation including: animal	These physical scores are listed in the animal care manual A. Body condition scores B. Hygiene scores C. Locomotion scores D. Hock assessments

Table 1. 1 Dairy cattle welfare programs

Program	Description	Areas of importance	Measurements
		comfort, equipment, loading, unloading, transportation factors, trucks, trailers, in-transit care, and specific life cycle considerations 7. Special needs animals including: nutrition, animal health, environment and facilities, handling, moving and transportation 8. Dairy breed including: dairy bull calves and freemartin heifers	

Table 1. 2 Management practices that have been associated with measurements of wellbeing in dairy calves

Practice	Consequence when not used	Measure of the Consequence	Outcomes of the measure	References (measure)
Use of Calving Pen	Increased stress	Fecal glucocorticoids Heart Rate Corticosteroids	Severe chronic stress may decrease individual fitness by immunosuppression and atrophy of tissues.	Faulkner and Weary, 2000 Hopster and Blokhuis, 1994 Mostl and Palme, 2002
	Decreased comfort	Lying behavior Time spent standing without eating	Uncomfortable cows spend less time lying down and more time standing idle. Thus decreasing the amount of time spent ruminating and resting.	Blackie et al., 2011 Haley et al., 2000 Hassall et al., 1993 Norring et al., 2008
	Decreased hygiene	Visual Cleanliness Score	Dirty cows have a higher risk of diseases, such as mastitis. Resulting in a higher somatic cell count.	Fregonesi and Leaver, 2001 Norring et al., 2008 Reneau et al., 2005 Sant' Anna et al., 2011 Schreiner and Ruegg, 2003 Tucker et al., 2001
Use of individual calving pen	Increased diarrhea (Frank and Kaneene, 1993)	Diarrhea incidence density	Diarrhea is associated with dairy calf morbidity	National Animal Health Monitoring System, 1993
	Increased respiratory	Disease incidence	Calf hood respiratory	Svensson et al., 2003

Table 1. 2 Management practices that have been associated with measurements of wellbeing in dairy calves

Practice	Consequence when not used	Measure of the Consequence	Outcomes of the measure	References (measure)
	problems (Svensson et. al., 2003)	Records	disease is associated with an increased occurrence of dystocia at first calving	
	Increased salmonella infections (Losinger et al., 1995)	Fecal specimen for bacteriology	Associated with dairy calf morbidity and zoonotic disease	National Animal Health Monitoring System, 1993
Feeding Colostrum	Lack of IgG absorption	Measuring passive transfer via the calf's blood (serum proteins)	Concentration of antibodies Immunoglobulin concentrations	Weaver et al., 2000 Vasseur et al., 2010
	Early neonate mortality	Newborn up to 21 day mortality rate	Mortality rate	Wells, Dargatz & Ott, 1996
Calf-Dam Separation	Exposure to environmental pathogens (Windsor and Whittington, 2010) Lack of maternal care, normal behavior (European Food Safety Authority, 2006)	Decreased immune function Calf social behavior Increased weight gain	Risk of exposure to infection and/or disease Allow normal behaviors, such as bonding between dam and newborn Increased calf health	European Food Safety Authority, 2006 Windsor and Whittington, 2010
Painful Procedures and use of pain control	Pain (Stafford and Mellor, 2005)	Heart rate Pupillary diameter Increased levels of cortisol	Behavioral changes (tail, wagging, head movements, tripping,	Faulkner and Weary, 2000 Molony and Kent,

Table 1. 2 Management practices that have been associated with measurements of wellbeing in dairy calves

Practice	Consequence when not used	Measure of the Consequence	Outcomes of the measure	References (measure)
			rearing, head rubbing, head shaking, and ear flicking)	1997 Stafford and Mellor, 2005
Weaning should be gradual and based on the calf's ability to eat solid food	Stress	Vocalization	Severe chronic stress may decrease individual fitness by immunosuppression and atrophy of tissues	Weary et al., 2008
	Weight loss	Growth rate	A decreased growth rate may reflect a stressful situation as well as increase the risk of immunosuppression.	Faulkner and Weary, 2000 Weary et al., 2008

Table 1. 3 Management practices that have been associated with measurements of wellbeing in dairy cows

Practices of the Cow	Consequences	Measurement of the consequence	Outcomes of the measure	References of the measure
Dirty Facilities (poor cleaning of stalls, inadequate bedding, high moisture content of the litter, poor kept dry cow facilities, the use of natural bodies of water for drinking)	Decrease hygiene Increased mastitis/ decreased milk quality (Schreiner and Ruegg, 2003)	Cleanliness Score	Dirty cows have a higher risk of diseases, such as mastitis. Causing a higher somatic cell count.	Fregonesi and Leaver, 2001 Norring et al., 2008 Reneau et al., 2005 Sant' Anna et al., 2011 Schreiner and Ruegg, 2003 Tucker et al., 2001
Housing Comfort	Lameness (Blackie et al., 2011)	Locomotion Score	Incidence of lameness	Barberg et al., 2007 Blackie et al., 2011 Flower and Weary, 2006 Haskell et al., 2006 Sprecher, et al., 1997
	Abnormal behavior (Haley et al., 2000)	Llying bouts Standing idle	Frequency of abnormal behaviors (including: increased standing time)	Blackie et al., 2011 Haley et al., 2000 Hassall et al., 1993 Norring et al., 2008
	Hock lesions (Regula et al., 2004)	Skin alterations at the hock	Incidence of hock lesions	Krebs et al., 2001 Norring et al., 2008 Regula et al., 2004 Rutherford et al., 2008 Zurbrigg et al., 2005

Table 1. 3 Management practices that have been associated with measurements of wellbeing in dairy cows

Practices of the Cow	Consequences	Measurement of the consequence	Outcomes of the measure	References of the measure
	Teat injuries (Regula et al.,2004)	Visual and manual inspection for injuries and scars	Incidence of teat injuries	Bewley et al., 2001 Regula et al., 2004
	Cleanliness (Regula et al., 2004)	Cleanliness score	Cleanliness is an indicator of dirty stalls, inadequate bedding, high moisture of the bedding, high stocking densities, poor maintained facilities	Fregonesi and Leaver, 2001 Norring et al., 2008 Reneau et al., 2005 Sant' Anna et al., 2011 Schreiner and Ruegg, 2003 Tucker et al., 2001
Diet management	Over/under conditioned cows	Body Condition Score	Body condition score is positively associated with mortality rates	Barberg et al., 2007 Berry et al., 2007 Edmonson et al., 1989 Ferguson et al., 1994 Roche et al., 2004 Roche et al., 2009 Wildman et al., 1982
Rough handling of livestock	Increased stress	Heart rate Fecal glucocorticoid Cortisol	Severe chronic stress may decrease individual fitness by immunosuppression and atrophy of tissues (Mostl and Palme, 2002)	Faulkner and Weary, 2000 Hopster and Blokhuis, 1994 Morrow et. al., 2002
	Injury	Locomotion scores	Incidence of lameness	Barberg et al., 2007

Table 1. 3 Management practices that have been associated with measurements of wellbeing in dairy cows

Practices of the Cow	Consequences	Measurement of the consequence	Outcomes of the measure	References of the measure
		# of slips when entering/exiting the parlor		Grandin, 2011 Sprecher, et al., 1997
	Fear	Flight Distance	Flight distance reflects a cow's fear of humans	Main et al., 2003 Uetke et al., 2002

Table 1. 4 Studies reporting methods for measurement of lameness in dairy cattle

Author	Objective	Location/Size	Measurement used	Results
Barberg et al., 2007	To develop descriptive data about the impact of using a bedded pack dairy barn on management practices, cow welfare, herd performance and udder health	Minnesota 12 dairy farms Avg. # of cows per farm 73 +/- 35.5	Used scale described by Sprecher et al., (1997)	7.8% of all cows were clinically lame (having a locomotion score ≥3 on a scale of 1-5)
Blackie et al., 2011	To examine the impact of chronic lameness on lying behavior of dairy cattle	United Kingdom A single herd 59 dairy cows	Used scaled described by Flower & Weary (2006)	Cows with a locomotion score ≥3 spent significantly more time lying down, less time standing and produced 7.9 liters less than non-lame cows
Flower and Weary, 2006	To explore how hoof pathologies affect dairy cattle gait	British Columbia University farm 48 dairy cows	a) 5 point numerical scale (1= smooth and fluid movement; 2= imperfect locomotion but ability to move freely no diminished; 3= capable of locomotion but ability to move freely is compromised; 4= ability to move freely is obviously diminished; 5= ability to move is severely restricted and must be vigorously encouraged to move) b) 6-specific gait attributes: Back arch, head bob, tracking-up, joint flexion, asymmetric gait, and reluctance to bear weight.	Cows affected by sole ulcers (4.0) had a poorer locomotion score than healthy cows (3.1). All the gait attributes were more pronounced for cows with sole ulcers compared to healthy cows, back arch (28 vs. 12), head bob (10 vs. 2), tracking-up (26 vs. 7), and reluctance to bear weight (32 vs. 16)

Table 1. 4 Studies reporting methods for measurement of lameness in dairy cattle

Author	Objective	Location/Size	Measurement used	Results
Haskell et al., 2006	To assess the effect of grazing vs. zero-grazing, level of milk production, and quality and type of housing system on the prevalence of lameness and leg injuries in dairy cows	Great Britain 37 dairy farms 2,724 cows	A 5 point scale: 1=sound (little or no limb adduction or abduction); 2=slightly uneven gait (some limb adduction or abduction); 3= lame (gait abnormality evident); 4= very lame (can be identified as lame from a distance); 5=extremely lame (cow is possibly recumbent or reluctant to stand)	Lameness was greater on zero-grazing (39) vs. grazing (15) and lameness scores were greater on freestall systems (0.25) vs. straw yard systems (0 .05)
Sprecher et al., 1997	To determine if a 5-point lameness scoring system would predict future reproductive performance and the risk of culling	Michigan Single herd 66 cows in	A 5-point scale: 1= normal (the cow stands and walks with a level-back posture, gait is normal); 2= mildly lame (cow stands with a level-back posture but has an arched-back while walking, gait remains normal); 3= moderately lame (an arched-back posture is evident both while standing and walking, gait is affected and is best described as short-striding with one or more limbs); 4= lame (an arched-back posture is always evident and gait is best described as one deliberate step at a time. The cow favors one or more limbs/feet); 5=severely lame (additionally demonstrates an inability or extreme reluctance to bear weight on one or more of her limbs/feet)	The prevalence of lameness (mean lameness score >2) was 65.2%.

Table 1. 5 Methods to measure hygiene of dairy cattle

Author	Objective	Location/Size	Measurement used	Results
Fregonesi and Leaver, 2001	To determine comparative indicators of welfare in the two most common loose-housing systems (strawyards and cubicles)	London University farm 24 dairy cows	A 6-point scale: 0= clean udder, belly, rear legs and tail; 1= clean udder, belly, rear legs, or tail with only minimal dirtiness; 2= udder with minimal dirtiness, belly rear legs or tail with some dirtiness; 3= udder with some dirtiness, belly, rear legs or tail dirty; 4= udder dirty, belly, rear legs or tail very dirty; 5= udder very dirty, belly, rear legs or tail very dirty	Cows in cubicle (0.3) were significantly cleaner than cows in straw yards (1.0)
Norring et al., 2008	To compare the effects of sand and straw bedding in free stalls on cleanliness	Finland Single farm 52 dairy cows	The teats, udder, belly, sides of belly and legs were evaluated separately, assigning 1 point for each area if there was any dirt or manure visible giving a maximum possible value of 10	Cows using straw stalls (6.04) were dirtier than cows using sand stalls (4.19)
Reneau et al., 2005	To develop a simple system for scoring hygiene in dairy cattle	Minnesota University farm 1191 dairy cows	A 5-point scale (1= very clean and 5=very dirty) and scored in 5 body areas: tail head, lateral aspect of the abdomen, udder, and lower portion of the hind limbs	The mean correlation coefficients for experienced evaluators ($\geq$0.884) and the students and faculty members (0.804) indicating high repeatability
Sant' Anna et al., 2011	To describe how the hygiene conditions of dairy cows vary over time and to assess whether a relationship exists between hygiene	Brazil 2 dairy farms 545 cows	A 4 point scale 1=very clean; 2=clean; 3=dirty; 4=very dirty; for four areas of the body: leg, flank, abdomen, and udder. The scores were then combined to generate a composite cleanliness score	The very clean cows had the lowest somatic cell scores followed by the clean dirty and very dirty cows, with 45.86% of cows being consistently clean and 9.76%

Table 1. 5 Methods to measure hygiene of dairy cattle

Author	Objective	Location/Size	Measurement used	Results
	and somatic cell count			being consistently dirty
Schreiner and Ruegg, 2003	To determine the relationship between udder and leg hygiene scores of lactating dairy cattle and measures of subclinical mastitis	Wisconsin 8 dairy farms 1250 cows	A 4 point scale 1= completely free of or has very little dirt; 2=slightly dirty; 3= mostly covered in dirt; and 4=completely covered caked on dirt	Mean hygiene scores were 2.09 for udders, and 2.33 for legs and an association exists for dirty cows and subclinical mastitis
Tucker et al., 2001	To determine whether tail docking would influence cow cleanliness and udder health in a free-stall system	British Columbia A single dairy herd 274 cows	A 5 x 17.5 cm wire grid with 14 equal square spaces was placed on the cow's back and the rump and the number of squares containing any debris was counted. The severity of soiling was a 4 point scale: 0=no debris; 1=flecks of debris; 2= a film or thicker chunks of debris; 3=thick caking of debris. Udder cleanliness was assessed by two scores: the number of teats with debris was counted and the same subjective score of (0-3 as described above)	Mean scores were rump: 1.56 docked, 1.53 for undocked Back: 1.46 docked, 1.52 for undocked. Cow cleanliness was not affected by docking however it was affected by time

Table 1. 6 Methods to assess body condition of dairy cattle

Author	Purpose of Study/ Article	Location/Size	Measurement used
Berry et al., 2007	To quantify the effect of periparturient body condition score and body weight related traits on the incidence of calving dystocia and stillbirths on body condition scores, body weight, milk production, udder health and fertility in Holstein Friesian dairy cows	New Zealand A single research farm 897 dairy cows	Body condition was assessed by palpating individual body parts and was recorded on a 10 point scale Roche et al., (2004)
Edmonson et al., 1989	To develop a chart for body condition scoring of freely moving Holstein dairy cows	California A single farm 72 dairy cows	Cows were examined using a 5 point scale with .25 unit increments: 1= emaciated condition 5= obese condition. On three major regions including: loin, pelvis and tail head
Ferguson et al., 1994	To assess the ability of four observers to independently assess body condition	Pennsylvania 400 dairy farms 225 cows	A 5 point scale with 0.25 increments and described several body regions including: the spinous and transverse processes of the lumbar vertebrae, the hook bone, pin bone, ileo-sacral and ischio-coccygeal ligaments, the tail head and the thurl region
Roche et al., 2004	To examine the relationships among differing body condition score systems	United States, Australia and Ireland 384 dairy cows	For cows in New Zealand and Ireland body conditions are assessed by palpation of individual body parts, compared to Australia and the United States where the same body parts are visually evaluated. The United States and Ireland use a 5 point scale (Wildman et al., 1982 and Edmonson et al., 1989), Australia uses a 8 point scale (Earle, 1976), whereas New Zealand uses a 10 point scale (Macdonald and Macmillan, 1993 and Macdonald

Table 1. 6 Methods to assess body condition of dairy cattle

Author	Purpose of Study/ Article	Location/Size	Measurement used
			and Roche 2004)
Waltner et al., 1993	To determine what relationships existed between body condition scores and production variables in high producing dairy cattle	Washington The State University 350 dairy cows and heifers greater than 15 months of age	The cows were assessed based on a five point scale (Wildman et al., 1982)
Wildman et al., 1982	To assess a body condition scoring system and its relationships to selected production characteristics	Virginia 29 dairy herds 812 cows	Cows were scored on appearance and palpation of back and hind quarters using a scale of 1-5: : 1=emaciated; 3=average; 5= obese

CHAPTER 2

2.0 COMPARISON OF SELECTED ANIMAL MANAGEMENT PRACTICES USED TO ASSESS WELFARE AMONG ORGANIC AND SIMILARLY SIZED CONVENTIONAL FARMS

2.1 ABSTRACT

Differences in adoption of selected practices used in welfare assessment/audit programs were contrasted among organic (ORG; n = 192) and similarly sized conventional grazing herds (CONGR; n = 36); and conventional non-grazing herds (CONNG; n = 64). The three programs used include, the American Humane Association (AHA), Farmers Assuring Responsible Management (FARM) and Canadian Codes of Practice (CCP). Information about neonatal care, dehorning, use of pain relief, preweaned calf nutrition, weaning, record keeping, use of veterinarians and animal observations was collected by trained study personnel during a herd visit. Associations of graze categories with adoption of selected practice were tested using Chi-square tests (categorical variables) or ANOVA tests (continuous variables). Only 57% of farms would have met requirements for feeding preweaned calves starter with ORG (70%) having the greatest proportion of farmers that fed starter compared to CONGR (33%) and CONNG (30%; $P < 0.001$). Overall, only 3% of farms did not meet the criteria suggested for weaning age; however, the least proportion of CONNG farmers weaned calves at ≥ 5 weeks of age as compared to ORG and CONGR farmers ($P = 0.006$). Overall, 72% of farms would have failed the welfare requirement to use pain relief while dehorning, but less CONNG farmers used pain relief as compared to ORG or CONGR. Organic farmers tended to feed more milk and wean calves at an older age compared to CONGR and CONNG farms ($P = 0.008$). Conventional graze farmers tended to dehorn calves at a younger age compared to ORG and CONNG farmers ($P = 0.026$) and thus were more likely to meet the requirements of the FARM program. The average proportion of cows scored as being over- or under-conditioned, lame, or having poor hygiene and hock

lesions far exceeded the minimum requirements for the American Humane Association and the Farm program. However, CONNG farms had the least proportion of cows scored as under-conditioned and the greatest proportion of cows scored as over-conditioned compared to ORG and CONGR farms ($P < 0.001$). While ORG farms had the least proportion of cows scored with hock lesions ($P < 0.001$). The smaller farms used in this study are unlikely to pass all the requirements made by common welfare programs and therefore, a more comprehensive way to assess welfare on dairy farms is needed.

2.2 INTRODUCTION

Dairy animal welfare audits and assessments are designed to reassure the consumer that farmers are using acceptable husbandry practices (Reynolds, 2006). People for the Ethical Treatment of Animals is an organization that initiated a major push for the creation of audits and assessments for animal agriculture (Eicher, 2006). In the late 1990's and early 2000's food companies, such as McDonalds and Wendy's, were targeted to require their suppliers to provide evidence of acceptable animal management practices. As a result, welfare audit and assessment programs became popular. Most programs collect information about: animal measures (such as body condition, lameness, hygiene and hock lesions), record keeping and general husbandry practices. Although similar animal measures are commonly assessed, differences in the adoption of these practices among organic and conventional farms have not been described.

There is great importance in developing methods to evaluate specific management practices that directly impact welfare such as: the calving environment (Vasseur et al., 2010),

management of colostrum (Wells et al., 1996; Weaver et al., 2000; Godden, 2008), pain management procedures (Faulkner and Weary, 2000), weaning (Jasper et al., 2008; Weary et al., 2008), housing environments (Rushen, 2001; Regula et al., 2004; National Farm Animal Care Council, 2009), nutrition (Burkholder, 2000; Roche et al., 2009), culling, mortality (Thomsen and Houe, 2006; Ahlman et al., 2011) and livestock handling (Hemsworth et al., 1989; Hemsworth et al., 1995). These management practices are the most challenging to maintain acceptable standards of animal wellbeing and currently there are no specific requirements for how to assess these practices in the United States. The aim of this study was to describe adoption of common management practices used to assess animal welfare among organic and conventional dairies.

2.3 MATERIALS AND METHODS

2.3.1 Data Collection for adoption of practices

Variables included in this assessment were selected based on requirements found in three common welfare programs including: American Humane Association (2012), National Dairy Farm Program (2012) and National Farm Animal Care Council (2009). These three programs, were chosen as they represent audits (AHA), assessments (FARM) and government regulations (CCP). Animal based variables were chosen from these programs to be assessed in this study as they directly influence dairy animal wellbeing.

Farm management data was collected for a study with the objective of assessing management of organic and small conventional dairy herds (Cicconi-Hogan et al., 2013; Richert et al., 2013a; Richert et al., 2013b; Richert et al., 2013c; Stiglbauer et. al., 2013).

Materials and methods for collection of data used to assess adoption of practices have been previously described (Cicconi-Hogan et al., 2013; Richert et al., 2013a; Richert et al., 2013b; Richert et al., 2013c; Stiglbauer et. al., 2013). In brief, organic (ORG) and similarly sized conventional (CON) herds in New York (n = 72 ORG; 25 CON), Oregon (n = 24 ORG; 24 CON), and Wisconsin (n = 96 ORG; 51 CON) were enrolled between April 2009 and April 2011. Herd eligibility criteria required a minimum of 20 cows and shipping milk to suppliers for at least two years. Organic herds had to be shipping certified organic milk for a minimum of two years. Herds were categorized into 3 graze categories that combined management system (ORG & CON) and grazing routine. Conventional Grazing (CONGR) herds were defined as conventional herds, in which lactating cows obtained ≥ 30% of DMI from pasture. Conventional non-grazing (CONNG) herds did not meet this definition. A single farm visit was made by 1 of 3 trained assessors and a 54 page questionnaire was administered (available at http://milkquality.wisc.edu/organic-dairies/project-c-o-w/). The questionnaire contained information about usage of veterinarians, milk quality protocols and calf management practices. In addition to the questionnaire, study personnel assessed body condition (BCS) (Ferguson et al., 1994), udder hygiene (UHS) (Schreiner and Ruegg, 2003), hock lesions (Fulwider et al., 2007), and lameness (Sprecher et al., 1997). Cows were considered lame when lameness score was ≥ 3. Study approval was obtained from the Institutional Review Board and Animal Care and Use Committee at Oregon State University.

2.3.3 Statistical Procedures

Statistical analysis comparing adoption of practices were run using SAS 9.3 (SAS Institute, 2011). Descriptive statistics were run using PROC FREQ and PROC

UNIVARIATE for categorical and continuous variables, respectively. Frequencies were analyzed for associations among graze categories using Chi-square tests (PROC FREQ) or Fisher's exact (if frequencies were less than 5). Non-parametric means among graze categories were tested for significant differences using PROC NPAR1WAY and then differences among means were tested using least significant differences (LSD) based on the ranks. Statistical significance was defined as $P \leq 0.05$.

2.4 RESULTS

Associations among selected management practices of calves and graze categories were analyzed (Table 2.1). Overall, 61% of farms disinfected navels of newborn calves and there was no association of this practice with graze category ($P = 0.320$). Only 57% of farms reported feeding preweaned calves starter and a greater proportion of ORG farms (70%) fed starter as compared to CONGR (33%) and CONNG (30%), $P < 0.001$). The ability of calves to turn around was observed on 85% of farms and was not associated with graze category ($P = 0.670$). Common methods used to dehorn included: chemical paste, hot iron and scoop, gouge or cut out and the type of method used was associated with graze category (Table 2.1; $P = 0.018$). In general, a greater proportion of organic farms used the scoop/gouge or cut method as compared to conventional herds (Table 2.1). Overall only 23% of farms utilized pain relief (local, NSAID or sedation) and 4% of ORG farmers reported using homeopathic remedies for pain relief while dehorning and associations were found among graze categories ($P = 0.009$). A greater proportion of organic farms (33%) used pain relief as compared to the conventional farms, however only ORG farmers reported using homeopathies (Table 2.1). Calving areas used were reported by farmers as follows: dedicated calving area, separate area

from lactating cows, separate area from sick cows or the same area as lactating cows and was significantly different among graze categories ($P = 0.003$). The proportion of ORG farms was least for the use of a dedicated pen, compared to conventional farms, whereas, CONGR had the least proportion of farms with an area separate from lactating cows (Table 2.1).

The average amount of colostrum fed, time until first feeding of colostrum and frequency of feeding milk to preweaned calves did not differ among graze categories ($P > 0.390$). Organic producers fed calves a greater quantity of milk as compared to conventional producers (Table 2.2; $P = 0.008$). The mean age at weaning was greater for calves on ORG farms as compared to calves on farms using CONGR and CONNG management (Table 2.2; $P < 0.001$). Calves were dehorned at a younger age on CONGR farms as compared to the age of calves dehorned on ORG and CONNG (Table 2.2; $P = 0.026$) farms.

A significant difference was found among the mean proportion of cows that were scored as over- or under-conditioned and graze category (Table 2.3; $P < 0.001$). The proportion of cows scored as being under-condition was least for CONNG farms as compared to the proportion of cows on ORG and CONGR farms (Table 2.3). Conventional non-graze farms had the greatest proportion of cows scored as being over-conditioned compared to the proportion of cows on ORG and CONGR farms (Table 2.3). No difference among the proportion of cows scored as having poor hygiene or being lame and graze categories was found ($P \geq 0.116$). However, ORG farms had the least proportion of cows with hock lesions compared to CONGR and CONNG farms (Table 2.3; $P < 0.001$).

Several associations were found among the proportion of farms with specific welfare requirements (i.e., records, veterinarians, and protocols) and graze categories (Table 2.4). No association was observed among graze category and the use of written health records.

However, greater proportion of ORG farmers (79%) reported use of written treatment records as compared to CONGR (28%) and CONNG (30%; $P < 0.001$). The proportion of farms with regular use of a veterinarian was greater for CONNG farms (77%) as compared to the proportion of CONGR (56%) and ORG (36%) farms ($P < 0.001$). Only 13% of farmers used veterinarians to train personnel, and this proportion was not associated with graze category ($P = 0.306$). The proportion of farmers that used a veterinarian to develop treatment protocols was least for ORG (28%) herds as compared to CONGR (53%) and CONNG (66%; Table 2.4; $P < 0.001$). No associations were found among the proportion of farms with written protocols for clinical mastitis or use of a written milking routine and graze category ($P \geq 0.167$).

2.5 DISCUSSION

Several common auditing/assessment programs are used to assure consumers that farmers are providing good welfare for dairy animals. For example, commonly used programs in North America include, the AHA program, FARM program and the CCP. The AHA was the first third-party audit system in the United States and is recognized by the USDA. The FARM program is an assessment program and is recognized by the USDA and the CCP was chosen to compare as the requirements reflect legal regulations in Canada. The AHA program is an audited program that includes extensive documentation of record keeping and employee management. The goals of AHA are to identify corrective actions and develop timetables for areas that do not comply with the animal welfare standards (American Humane Association, 2012). Farmers Assuring Responsible Management (FARM) is an assessment program with a verification of some assessed farms using second-party

evaluation. The evaluation results are to provide the dairy farmer with a status report and help develop an action plan for improvement, if necessary. The National Dairy FARM program was developed by the National Milk Producers Federation with the support of Dairy Management, Inc. (National Dairy Farm Program, 2012). The FARM program was designed to demonstrate the commitment farmers make to use responsible management practices. In total there are 36 management checklist points and the evaluated farms will participate in a random sample of third-party verification. The third-party verification is designed to test the integrity of the program's animal care best practices. There is no pass or fail for this program and standards are not necessarily supported by scientific evidence. The CCP for the Care and Handling of Farm Animals for dairy cattle was created by the Canadian National Farm Animal Care Council (2009). The codes were developed by a development committee and a scientific committee in order to create a code that is scientifically informed, practical, and reflects societal expectations for farm animal care that can be supported by expert opinion and scientific evidence. Currently the CCP is not an assessment program, but can be used as a reference for legal regulations and best recommended practices. Although these programs may be popular, how they influence welfare may be questionable. These three programs were chosen to compare requirements as they are representative of audits, assessments and government regulations. The animal based variables chosen to compare in this study are those that can directly influence dairy animal wellbeing.

Veterinarian Usage. Auditing and assessment programs commonly include requirements for veterinary involvement, animal health and management, humane handling of cattle, stockperson training, housing, feeding and transportation (National Farm Animal Care Council, 2009; American Humane Association, 2012; National Dairy Farm Program,

2012). The role of the veterinarian in providing animal health care is typically stressed but, recent research using the same dataset used in this project reports that most animal diseases are diagnosed and treated without input by veterinarians (Richert et al., 2013). Auditing and assessment programs also commonly enforce the importance of having an animal health plan (National Farm Animal Care Council, 2009; American Humane Association, 2012; National Dairy Farm Program, 2012). For example, the AHA program requires that a health plan is developed in consultation with the herd veterinarian and it must include: vaccination protocols, treatment protocols, tolerance limits for overall animal health, causes of morbidity and mortality, biosecurity measures for new animals entering the herd, action plans to remedy problems and mitigate recurring injuries, mastitis control, and monitoring of herd performance parameters. The FARM program also requires that farmers work with a herd veterinarian to develop an animal health plan that is reviewed and updated annually. The herd health plan must include protocols for: vaccinations, daily observations of all cattle for injuries or signs of disease, newborn calf management, milk fed calf management, painful procedures, cattle that develop disease or injuries, dystocia, prevention and detection for common diseases, parasites and pest control, fly control, non-ambulatory animal management (including proper movement, use of special equipment, husbandry and nursing care, shelter, water, feed, isolation, protection and prompt medical care), euthanasia (including training of caretakers for the need and recognition of animals to be euthanized, proper technique training, confirmation of death, record keeping, disposal of carcasses in compliance with local regulation), food safety and training programs for animal caretakers. The CCP does not require a herd health plan however, appropriate authorities are to be advised of any suspect or confirmed cases of reportable disease, when animals are culled

appropriate drug withdrawal time must be observed and feet and claws must be inspected and trimmed as required to minimize lameness. In our dataset, only a minority of farms would have met the requirements for regular use of veterinarians. Only 47% of farms included in this study reported regular use of veterinarians and organic farms were the least likely to have regular use of a veterinarian. In addition, protocols were developed by veterinarians on only 39% of farms and personnel were trained by a veterinarian on only a minority (13%) of farms. Richert et al. (2013), commented that use of veterinarians was more associated with intensive management practices such as use of a nutritionist, use of artificial insemination, having cows checked for pregnancy and use of vaccinations as compared to organic or conventional management practices. In addition, the authors discovered that 40% of the 199 farmers included in the study reported having routine veterinarian visits during a 120 day observation period. The routine veterinarian visits consisted mostly of reproductive work followed by routine work (such as dehorning and vaccinations), examination and treatment of sick animals and consulting. There is a need for veterinarians to be more active on the small farms that constituted our study population as veterinarians provide diagnoses of disease and appropriate treatments.

Mastitis is the most common disease in dairy cattle and can negatively impact welfare (Leslie and Petersson-Wolfe, 2012). In addition to the animal health plan, the AHA program requires a written policy for the control of mastitis, in which all cases of mastitis must be identified and treated. In addition, the herd somatic cell counts (SCC) must be monitored at the bulk tank level and where SCC exceed 375,000 cells/mL for any 2-month period, the specific organisms involved must be identified and an appropriate program for mitigation must be maintained until SCC drop to acceptable levels. Neither the FARM program nor the

CCP have a specific requirement for the control of mastitis. Although having a milking routine or a written protocol for clinical mastitis did not differ among graze categories, only 12% had written protocols and 15% had a written milking routine. Therefore, at least 75% of our farms would not have met the AHA criteria for a mastitis control plan.

Calf care. Many management practices can influence calf welfare such as neonatal care, colostral management, preweaned calf care and weaning management. Dipping of neonatal navels is a recommended practice by veterinarians to decrease the risk of navel infection (Mee, 2008). Both the AHA and FARM programs have requirements for dipping navels of new-born calves using an appropriate disinfectant. The CCP do not have a requirement for navel dipping, although it is included in the recommendations. Overall 61% of the farms in this study would have met the criteria for dipping calf navels, although no association was observed with graze categories.

Calves are born without immunity; therefore, it is vital to receive good quality colostrum in a quantity that is about 10% to 15% of the calf's body weight (Godden, 2008), which is equivalent to a minimum of two liters for smaller calves and a minimum of four liters for normal to larger calves (Weaver et al., 2000). Colostrum should be given within six hours of life (Weaver et al., 2000; Vasseur et al., 2010). All 3 auditing/assessment programs have requirements for consumption of colostrum but the amount of colostrum required varies among the three welfare programs. In this study the amount of colostrum given was 2.72, 2.81 and 2.78 liters for ORG, CONGR and CONNG, respectively. Therefore, the average amount of colostrum fed would have met the AHA and the FARM standards, but not the CCP. On average all farms gave colostrum less than six hour after birth and would have met the criteria for all three programs.

Feeding calves amounts of milk larger than the traditional 10% to 12% of body weight per day, can increase growth, accelerate age at first calving, improve mammary development and increase milking production during the first lactation (Jasper and Weary, 2002; Rincker et al., 2006). In addition to milk, calves require solid food to properly develop rumen function. The AHA and FARM programs have requirements for preweaned calf care, such as milk consumption, water and feed requirements, whereas the CCP only have requirements for milk consumption. While the amount of milk fed daily differed significantly among graze categories, the volume was sufficient to meet requirements of all programs and the average number of feedings per day would have met the AHA criteria. Organic farmers were more likely to feed preweaned calves starter compared to CONGR and CONNG farmers. However, only 57% of the herds in this study would have met the criteria for the AHA and FARM programs for feeding preweaned calves starter.

Weaning is potentially the first stressful feeding transition for young calves (Weary et al., 2008; Vasseur et al., 2010). To avoid stress, such as excessive vocalization, decreased feed intake and weight loss, weaning should be performed gradually and based on the animal's ability to eat solid food rather than age (Jasper et al., 2008; Weary et al., 2008; Vasseur et al., 2010). Of the three programs only the AHA has requirements for weaning and requires calves must receive milk until at least 5 weeks of age. Conventional non-graze herds had the greatest proportion of herds that weaned calves prior to 5 weeks of age. Overall 97% of herds would have met these requirements for the AHA.

Calf housing can take many forms. According to National Animal Health Monitoring System (2007) most calves are housed in individual pens or hutches indoor (67.9%), or multi-animal pens (14.2%). While each of the 3 audit/assessment programs includes general

recommendations for calf housing, only the AHA program and the CCP require that calves have the freedom to stand up, turn around and lie down. Overall, 85% of the farms in this study would have met the criteria of being able to turn around with no association observed among graze categories.

Husbandry procedures such as supernumerary teat removal, dehorning, castration, tail docking and other surgical procedures can be painful and negatively affect animal welfare. The AHA program and the CCP have specific requirements for husbandry procedures such as supernumerary teat removal, castration and tail docking, whereas all three programs have specifications for dehorning. Only 23% of the farms would have met the pain relief requirements for all three programs. In addition, only ORG farmers (21%) reported using homeopathic remedies for pain relief. In comparison only CONGR farms on average dehorned at a young enough age to meet the FARM requirements. For the AHA age requirements, 7 farms reported using chemical paste after 7 days of age and burning with a hot iron was used on 125 farms after one month of age. Therefore, 46% of the farms in this study would not have met these specific requirements. In addition, the scoop gouge or cut out method was used on 17% of farms and of those farms only 26% of farmers reported using pain relief. Thus, indicating another area of concern for dairy calf wellbeing.

Where the calf is born may also influence its health and wellbeing. There is an increased risk of disease if a calf is exposed to a poor environment such as one that causes increased stress, decreased hygiene or decreased comfort (Lago et al., 2006). According to the AHA the calving area must have materials that are smooth, impervious to water and cleanable. In addition, the area must have a means to humanely restrain the cows and provide insulation, ventilation and warmth. The FARM program requires the calving area

must be clean, dry, well-lit and well-ventilated. In comparison the CCP specifies that the calving area be clean prior to and after delivery of the calf. In our study, 30% of farmers reported using a dedicated calving area. When farmers provided a dedicated area, it is more likely to provide the dam and calf with an area which accommodates to their needs.

Animal based measures. Animal based methods are commonly used to measure welfare as a reflection of management and housing. For example, housing can have a major impact on dairy cattle welfare and if not designed properly or maintained, cows may become injured and develop lameness (Rushen, 2001), develop hock lesions (Regula et al., 2004; Rutherford et al., 2008), exhibit abnormal behaviors (Haley et al., 2000; Blackie et al., 2011), experience teat injuries (Regula et al., 2004) or become dirty (Regula et al., 2004). In addition, body condition is commonly measured as a reflection of the proportion of body fat and thus nutritional management (Roche et al., 2009). Of the three programs the AHA has 9 total animal based measures including: udder condition, incidences of slips and falls, lameness, hygiene, leg condition (hock), coat condition, tail condition and body condition. In comparison the FARM program has 4 animal based measures including: body condition, lameness, hock lesions and hygiene. Since the CCP is neither an audit nor an assessment program, no specific animal based measures are required, although it is specified that lame cows are to be diagnose early and either treated, culled or euthanized, as well as producers are to take corrective action for animals with a BCS of 2 or lower.

The AHA specifies that all lactating and dry cows must be scored for lameness and no more than 5% score > 2 on a 5-point scale. The FARM program requires that no more than 5% of the herd score > 2 on a 3-point scale. The average farms in this study exceed these requirements of lameness across all three graze categories. In comparison, a study that

looked at 30 dairy herds in Wisconsin reported a mean prevalence of 21-24% lameness (Cook, 2003). Whereas, a study that surveyed producers across 113 North Central and North Eastern Dairies across the United States reported a range of 0 – 10% lameness in cows (Fulwider et al., 2008); however, these results were reported from farmer observation rather than scored by study personnel. These studies indicate that the requirements for lameness according to the AHA and the FARM program would result in many farmers failing as the mean prevalence of lame cows far exceeds 5%.

Animal hygiene requirements for AHA specify 90% percent of all cows must have a hygiene score of 1 or 2 on a 4-point scale. In comparison, the FARM program requires that 90% of all cows score 1 or 2 on a 4-point scale. While no difference was observed among graze categories in this study, on average farms would not have met this requirement as the proportion of cows that scored 3 or 4 was > 30%. In comparison, a study measuring udder and leg hygiene across 8 commercial Wisconsin dairies reported a mean hygiene score of 2.09 and 2.33 for udders and legs, respectively and almost 30% of cows were scored as either a 3 or 4 (Schreiner and Ruegg, 2003). Another study comparing bedding types on 100 dairies across Wisconsin, Minnesota, Indiana, Iowa and New York reported that the average percentage of cows scored as 3 & 4 exceeded 15% of all types of bedding evaluated (Fulwider et al., 2007). Based on these studies, it is unlikely that an independent observer would find many herds that could reach the requirements for animal hygiene that currently exist in the AHA and the FARM programs.

The leg condition score for the AHA is based on a 4-point scale and requires that 90% of all lactating cows have a leg condition score of either 0 or 1; in addition, scores of 1, 2 or 3 may not exceed 10% and scores of 2 or 3 cannot exceed 2% of all lactating cows. The

FARM program requires that 95% of the herd must have a hock score of 2 or less (on a 3-point scale). On average the proportion of cows scored as having hock lesions (score 2 & 3) far exceeded the requirements of both programs and therefore few farms would have passed this criteria. Organic herds tended to have the least proportion of cows scored as having hock lesions, although on average only 85% of cows on ORG farms had a score of 1. In comparison, Lombard et al. (2010) measured hock lesions on cows housed in freestalls across 17 states in the United States had and reported about 13% of cows had a hock score of 2 or 3 out of a 3 point scale. Another study conducted on cows housed on bedded packs in Minnesota measured hock lesions and reported about 25% of cows had a hock score of 2 & 3, with only 1% having a severe lesion (score 3). As these studies few farms would meet the current requirements for the AHA and the FARM programs.

The AHA requires body condition to be measured on a 5-point scale by Edmonson et al. (1989) and 98% of the lactating cows must have a BCS between, 2.0 and 4.5. Body Condition for the FARM program is measured on a 5 point scale and requires that 99% or more of all animals must have a BCS of 2.0 or more. Although CONNG herds had the least proportion of cows scored as being under-conditioned (≤ 2.25) these farms still did not meet the minimum requirements of either the AHA or the FARM program. In addition, CONGR and ORG had the least proportion of cows scored as being over-conditioned (≥ 4) and were greater than the minimum requirements for the AHA. These farms may have not met the requirements due to the difference in scores required by the two programs and the score used to assess the cow's body condition. Without the use of 0.25 increments rounding is used to create a whole number for the body condition score. Sato et al. (2005), conducted a study on organic and neighboring conventional dairies in Southwestern Wisconsin measuring body

condition during the spring and fall. The authors reported the mean body condition score for organic farms (BCS = 2.58) was significantly less compared to conventional farms (BCS = 2.81) during the spring; although no difference was observed during the fall. However, the authors did not report body condition at the herd level and thus makes it difficult to compare how many farms would have met the criteria for the AHA and the FARM program. Audits and assessments should take into consideration animals that are over-conditioned, because they are more prone to metabolic diseases and should not be ignored. Further research may be necessary to determine more appropriate thresholds for these animal based measures.

2.6 CONCLUSION

Management practices and animal based measures from 292 ORG and CON dairies were compared to requirements of three welfare programs. Most farms would not have met the requirements for animal based measures such as body condition, lameness, hygiene and hock lesions. The use of veterinarians was minimal, although CONNG herds had the greatest proportion of farmers that reported regular use of veterinarians. In addition, very few farms maintained written protocols for clinical mastitis or milking routines. Management areas of concern that did not meet the full requirements of the three welfare programs include, amount of colostrum, dipping of calf navels, feeding preweaned calves starter, age at dehorning and the use of pain relief. As this study shows the smaller farms included in this study are less likely to pass the requirements made by common welfare programs. The actual impact of these program requirements on animal welfare is unknown.

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Table 2. 1 Proportion of farms that use specified categorical management practices and requirements of three welfare programs

	Welfare Program				Graze Category			
	AHA[1]	FARM[2]	CCP[3]			ORG[4] (n=192)	CONGR[5] (n=36)	CONNG[6] (n=64)	
Management practices	Requirement of program			Outcome	Overall	Freq. (%)	Freq. (%)	Freq. (%)	P-value
Disinfection of calf navels	Yes	Yes	No	Met	61%	113 (59%)	26 (72%)	39 (61%)	0.320
Feeding preweaned calves starter	Yes	Yes	No	Met	57%	134 (70%)	12 (33%)	19 (30%)	<0.001
Weaning Age	≥ 5 wks.	No	No	Met	97%	190 (99%)	35 (97%)	58 (91%)	0.006
Ability to turn around[7]	Yes	No	Yes	Met	85%	136 (84%)	28 (88%)	53 (88%)	0.670
Method used to dehorn[8]	Yes[9]	No	No	Chemical paste	5%	7 (4%)	6 (17%)	3 (5%)	0.018
				Hot iron	77%	142 (75%)	27 (75%)	53 (83%)	
				Scoop, gouge, or cut them out	18%	40 (21%)	3 (8%)	8 (12%)	
Use of pain relief for dehorning[10]	Yes	Yes	Yes	Local, NSAID or sedation	23%	49 (26%)	10 (28%)	8 (13%)	0.009
				Homeopathic	4%	13 (21%)	0 (0%)	0 (0%)	
Calving Area[11]	Yes	Yes	Yes	Dedicated area	30%	46 (24%)	16 (44%)	26 (41%)	0.003
				Separate from lactating cow	18%	39 (20%)	2 (6%)	13 (20%)	
				Separate from sick cows	14%	23 (12%)	6 (17%)	11 (17%)	
				Same as lactating cows	38%	84 (29%)	12 (33%)	14 (22%)	

[1] American Humane Association.

[2] Farmers Assuring Responsible Management.
[3] Canadian Codes of Practice.
[4] Organic farms.
[5] Conventional grazing farms.
[6] Conventional non-grazing farms.
[7] Information was available for 162, 32, and 60, for Organic, Congraze, and Connongraze herds, respectively.
[8] Information was available for 189, 36, and 64, for Organic, Congraze, and Connongraze herds, respectively.
[9] Scoop, gouge or cut out method is not permitted unless performed by a veterinarian with local anesthetic and NSAID.
[10] Information was available for 189, 36, and 63, for Organic, Congraze, and Connongraze herds, respectively.
[11]All programs require a clean environment for dams to calve in.

Table 2. 2 Calf management practices reported by graze category and requirements of three welfare programs

	Welfare Program					Graze Category			
	AHA[1]	FARM[2]	CCP[3]			ORG[4] (n=192)	CONGR[5] (n=36)	CONNG[6] (n=64)	
Variable (Continuous)	Requirement of program			Measurement	% of farms that met the requirement	Mean (SE)	Mean (SE)	Mean (SE)	P-value
Total amount of colostrum[7]	2–4 liters	Adequate amount	4 liters	liters	AHA = 50% CCP = 4%	2.72 (1.04)	2.81 (1.49)	2.78 (1.17)	0.895
Time of first colostrum[8]	≤ 6 hrs.	Soon after birth	≤ 6 hrs.	Hours	AHA=86% CCP=86%	4.48 (3.55)	3.88 (3.28)	4.67 (4.03)	0.391
Frequency of feeding milk to preweaned calves[9]	2x/day	No	No	Times/day	AHA=99%	2.02 (0.25)	2.03 (0.17)	2.05 (0.21)	0.479
Amount of milk fed to preweaned calves[10]	No	Adequate amount	Adequate amount	Liters	FARM=100% CCP=100%	5.48 (1.64)[a]	4.84 (1.60)[b]	4.84 (1.51)[b]	0.008
Age at weaning[11]	≥ 5 wks.	No	No	Weeks	AHA=98%	11.59 (4.06)[a]	8.28 (2.35)[b]	8.04 (2.48)[b]	<0.001
Age at dehorning[12]	≤ 8 wks.	≤ 8 wks.	No	Weeks	AHA=61% FARM=61%	10.15 (9.19)[a]	6.11 (4.52)[b]	9.67 (6.47)[a]	0.026

[a – c] Variable means with different subscripts differ significantly within rows (P ≤ 0.05).

[1] American Humane Association.

[2] Farmers Assuring Responsible Management.

[3] Canadian Codes of Practice.

[4] Organic farms.

[5] Conventional grazing farms.

[6] Conventional non-grazing farms.
[7] Information was available for 169, 33and 64, for ORG, CONGR, and CONNG herds, respectively.
[8] Information was available for 188, 32, and 64, for ORG, CONGR, and CONNG herds, respectively.
[9] Information was available for 181, 36, and 63, for ORG, CONGR, and CONNG herds, respectively.
[10] Information was available for 181, 36, and 62, for ORG, CONGR, and CONNG herds, respectively.
[11] Information was available for 190, 36, and 63, for ORG, CONGR, and CONNG herds, respectively.
[12] Information was available for 190, 36, and 63, for ORG, CONGR, and CONNG herds, respectively.

Table 2. 3 The proportion of cows scored on farms as having conditions commonly assessed in three welfare programs

	Welfare Programs					Graze Category			
	AHA[1]	FARM[2]	CCP[3]			ORG[4] (n=192)	CONGR[5] (n=36)	CONNG[6] (n=64)	
Variable (Continuous)	Requirement of program			Measurement	% of farms that met the requirement	Mean (SE)	Mean (SE)	Mean (SE)	P-value
Proportion of cows scored as over-conditioned[7]	98% ≤ 4.5	No	No	BCS ≥ 4	AHA=31%	7.4% (8.70)[a]	10.3% (10.96)[a]	13.8% (10.26)[b]	< 0.001
Proportion of cows scored as under-conditioned[8]	98% > 2	99% > 2	Diagnosed	BCS ≤ 2.25	AHA=27% FARM=20%	10.4% (12.02)[a]	7.5% (5.97)[a]	4.5% (4.95)[b]	< 0.001
Proportion of cows scored with poor hygiene [9]	90% ≤ 2	90% ≤ 2	No	UHS 3 & 4	AHA=21% FARM=21%	33.5% (23.03)	32.9% (21.80)	36.0% (22.80)	0.725
Proportion of cows scored as being lame[10]	95% ≤ 2	95% ≤ 2	Diagnosed	LS ≥ 3	AHA=43% FARM=43%	7.6% (0.07)	6.6% (0.06)	9.9% (0.09)	0.116
Proportion of cows with hock lesions[11]	90% ≤ 1	95% ≤ 2	No	HS 2 & 3	AHA=47% FARM=36%	15.1% (18.30)[a]	21.8% (20.69)[b]	30.5% (25.24)[b]	< 0.001

[a – c] Variable means with different subscripts differ significantly within rows (P ≤ 0.05).

[1] American Humane Association.

[2] Farmers Assuring Responsible Management.

[3] Canadian Codes of Practice.

[4] Organic farms.

[5] Conventional grazing farms.

[6] Conventional non-grazing farms.

[7] Cows were scored as being over-conditioned with a body condition score (BCS) ≥ 4 (5 pt. scale with 0.25 increments).

[8] Cows were scored as being under-conditioned with a body condition score (BCS) ≤ 2.25 (5 pt. scale with 0.25 increments).

[9] Cows were scored as having poor hygiene with a udder hygiene score (UHS) of 3 & 4 (4 pt. scale).

[10] Cows were scored as being lame with a locomotion score (LS) of ≥ 3 (5 pt. scale).

[11] Cows were scored as having hock lesions with a hock score (HS) of 2 & 3 (4 pt. scale).

Table 2. 4 The proportion of farms with specific welfare audit requirements for records, veterinarian use and protocols

	Welfare Programs				Graze Category				
	AHA[1]	FARM[2]	CCP[3]			ORG[4] (n=192)	CONGR[5] (n=36)	CONNG[6] (n=64)	
Variable	Requirement of program			Outcome	Overall	Freq. (%)	Freq. (%)	Freq. (%)	P-value
Written Health Records	Yes	No	No	Met	95%	183 (95%)	33 (92%)	60 (94%)	0.497
Written Treatment Records	Yes	No	No	Met	62%	151 (79%)	10 (28%)	19 (30%)	< 0.001
Regular Use of a Veterinarian	Yes	Yes	Yes	Met	47%	69 (36%)	20 (56%)	49 (77%)	< 0.001
Training of Personnel by a Veterinarian	Yes	Yes	No	Met	13%	22 (11%)	4 (11%)	12 (19%)	0.306
Protocols Developed by a Veterinarian	Yes	Yes	No	Met	39%	54 (28%)	19 (53%)	42 (66%)	< 0.001
Written Protocol for Clinical Mastitis	Yes	No	No	Met	12%	25 (13%)	1 (3%)	9 (14%)	0.167
Written Milking Routine	Yes	No	No	Met	15%	28 (15%)	5 (14%)	11 (17%)	0.861

[1] American Humane Association.
[2] Farmers Assuring Responsible Management.
[3] Canadian Codes of Practice.
[4] Organic farms.
[5] Conventional grazing farms.
[6] Conventional non-grazing farms.

CHAPTER 3

3.0 PRACTICES ASSOCIATED WITH DAIRY CATTLE WELLBEING ON ORGANIC AND SIMILARY SIZED CONVENTIONAL DAIRY HERDS

3.1 ABSTRACT

Associations of management practices with indicators of dairy cattle wellbeing were studied on organic (ORG; n = 192), similarly sized conventional grazing herds (CONGR; n = 36); and conventional non-grazing herds (CONNG; n = 64) located in Oregon, New York and Wisconsin. During a herd visit, study personnel collected management data, scored calves for diarrhea and respiratory disease, and scored adult cattle for body condition, lameness, udder hygiene, and hock lesions. Retrospective (previous 60 days) and prospective (subsequent 60 days) animal health and culling data were collected. Information about housing, neonatal care, dehorning, use of pain relief, pre-weaned calf nutrition, weaning, and calving environment was collected. Data was combined to create welfare scores for adult cow health and calf health and management practices. Associations among welfare scores and predictor variables were evaluated using Logistic regression. No association was observed the calf health and management score and graze category. Conventional grazing herds were less likely to be categorized as having the best adult cow health as compared to ORG ($P = 0.002$). Herds located in NY and OR were more likely to be categorized as having the best adult cow health as compared to herds located in WI ($P < 0.001$). Farms with multi-animal pens or freestalls as the primary housing for adult cows were 4 times more likely to be categorized as having the best adult cow health as compared to farms that primarily housed adult cows in tie stalls or stanchions ($P = 0.034$). Farms with individual pens, hutches, multi-animal pens and freestalls as the primary housing for calves were at least 4 times more likely to be categorized as having the best calf health and management compared to farms that primarily tied calves in a barn for housing ($P = 0.017$). In conclusion, two scores were created to effectively discriminate among herds and may be useful to assess welfare of dairy animals.

3.2 INTRODUCTION

Ensuring the wellbeing of dairy cattle is of great importance for dairy producers and is an emerging concern of consumers. The five freedoms that were developed by the Farm Animal Welfare Council are considered to be the basis of assuring good welfare for farm animals (Farm Animal Welfare Council, 1993). These five freedoms are: 1) freedom from hunger, thirst and malnutrition, 2) freedom from discomfort, 3) freedom from pain, injury and disease, 4) freedom to express normal behavior, and 5) freedom from fear and distress. All five freedoms can be accomplished through proper management and care of dairy cattle. Several management areas contribute significantly to the wellbeing of dairy cattle: 1) providing a sufficient calving environment, 2) management of colostrum, 3) care of neonates, 4) appropriate separation of the dam and her calf, 5) the use of pain control during painful procedures, 6) weaning, 7) housing environment, 8) nutritional management, 9) prevention and treatment of disease and 10) culling decisions.

Safeguarding future productivity begins when the calf is born. Therefore, the calving environment plays an essential role in ensuring calf wellbeing. A number of management practices can influence the welfare of calves. Cows should calve in a clean, dry, warm and comfortable area and managers should minimize the level of stress during the periparturient period. Within six hours of birth, smaller calves should receive a minimum of two liters of colostrum, whereas larger calves should receive a minimum of four liters (Weaver et al., 2000; Vasseur et al., 2010). Calves should be housed in an environment which allows them to turn around, lie down, stand up, adopt normal resting postures, and have visual contact with other calves. Their environment should also provide warmth, dryness, and traction (National Farm Animal Care Council, 2009). Several common management practices have the potential to

influence animal welfare. Dehorning is a common practice and reduces the risk of injuries to farm workers and other animals (Faulkner and Weary, 2000). During this painful procedure, anesthetics or analgesics should be administered to mitigate pain (Faulkner and Weary, 2000). Calves should be dehorned before they reach two months of age so that less painful methods can be used. Hoe and Ruegg (2006) reported that only 18% of Wisconsin farmers used local anesthetics to mitigate pain and noted that the failure to use analgesics may be due to a lack of awareness of alternatives for pain relief. Weaning is another potentially stressful period (Weary et al., 2008). To avoid decreased feed intake, weight loss and excessive vocalization, weaning should be gradual and based on the calf's ability to eat solid food rather than solely based on age (Jasper et al., 2008; Weary et al., 2008; Vasseur et al., 2010; de Passillé and Rushen, 2012).

Similar to calves, welfare of adult cows is influenced by decisions made about housing, feeding, handling and disease management. If housing in not properly designed or maintained, cows may be injured, develop hock lesions (Regula et al., 2004; Rutherford et al., 2008), or become lame (Rushen, 2001). Poorly designed facilities may result in cows that exhibit abnormal behaviors (Haley et al., 2000; Blackie et al., 2011), develop teat injuries (Regula et al., 2004) or become dirty (Regula et al., 2004). Lameness has been reported to occur in about 14% of dairy cows in the United States (National Animal Health Monitoring System, 2007a). Lame cows are less productive and often exhibit abnormal behavior. Poor animal hygiene is also considered a welfare issue and can be affected by disease, climatic conditions and animal behavior (Sant'Anna and da Costa, 2011). Proper nutritional management is fundamental to maintaining dairy cattle health and productivity and energy balance is commonly measured using body condition scores (Wildman et al., 1982; Edmonson et al., 1989; Berry et al., 2007). Assessment of morbidity is also associated with dairy cow wellbeing (Thomsen et al., 2006;

Ahlman et al., 2011). Direct comparisons between objective measurements of animal welfare on organic and conventional dairies have not been published. The aim of this study was to use objective data to identify management practices associated with greater animal wellbeing on organic and similarly sized conventional dairy farms.

3.3 MATERIALS AND METHODS

3.3.1 Data Collection

The materials and methods have been previously described (Cicconi-Hogan et al., 2013; Richert et al., 2013a; Richert et al., 2013b; Richert et al., 2013c; Stiglbauer et. al., 2013). In brief, organic (ORG) and similarly sized conventional (CON) herds in New York (n = 72 ORG; 25 CON), Oregon (n = 24 ORG; 24 CON) and Wisconsin (n = 96 ORG; 51 CON) were enrolled in this study between April 2009 and April 2011. Herds included in the study had a minimum of 20 cows and had been shipping milk to suppliers for at least two years. Organic herds were required to have been shipping certified organic milk for a minimum of two years. Herds were categorized into 3 graze categories, which combined management system (ORG & CON) and grazing routine. Conventional Grazing (CONGR) herds were defined as conventional herds that received ≥ 30% of DMI for lactating cows was obtained from pasture. Conventional herds that did not meet this criterion were defined as conventional non-grazing (CONNG). A single farm visit was made by 1 of 3 trained assessors and a 54 page questionnaire was administered (available at http://milkquality.wisc.edu/organic-dairies/project-c-o-w/). During the farm visit, study personnel assessed calf health by scoring the occurrence of coughing, eye discharge, nasal discharge, droopy ears or diarrhea (McGuirk, 2008). A calf was considered to have nasal discharge when both nostrils had mucus discharge. Droopy ears were defined as either slight

unilateral droop or a head tilt and bilateral droop. Calves that were observed with moderate or heavy ocular discharge were recorded as having eye discharge. Coughing was recorded when at least one calf coughed while moving. A calf with loose or watery manure was considered to have diarrhea. In addition, the ability of a calf to turn around in its housing was recorded.

Adult cow health was assessed using scoring systems for body condition (BCS) (Ferguson et al., 1994), udder hygiene (UHS) (Schreiner and Ruegg, 2003), hock lesions (Fulwider et al., 2007), and lameness (Sprecher et al., 1997). A cow was considered to have a dirty udder when her udder received a score ≥ 3. Hock lesions were defined when the hock score was ≥ 2. Cows were considered to be over-conditioned when the BCS > 4 and cows were considered under-conditioned if when the BCS < 2.5. Cows were considered lame when they were scored as moderate to severely lame.

Farm records and recall of the farmers was used to record the occurrence of animal health events and culling for the 60 days prior to the study. Prospective data on animal health and culling were recorded for 60 days after the visit using diaries provided by the researchers. Study approval was obtained from the Institutional Review Board and Animal Care and Use Committee at Oregon State University.

3.3.2 Definition of Variables

Two scores were created to assess dairy cattle wellbeing: 1) adult cow health events score and 2) calf health and management score. For each of the scores, points were assigned when selected variables exceeded population thresholds that were defined in this study. Greater points infer that objective scores of each variable are superior as compared to other herds in this database. The total points within each category were then summed for each farm to calculate a total adult cow health score and a calf health and management score. The 75^{th} percentile was

used to delineate the herds with the greatest animal welfare. The maximum points were 6 and 8.5 for cow health events score and calf health and management score, respectively.

The adult cow health events score included data on diseases observed, treatments and health management procedures on adult cows during the retrospective and prospective collection period. Treatments were counted even if they resulted in no milk being withheld. Examples of health events include: hoof trimming, administration of garlic for high SCC, administration of aloe for metritis and cooper sulfate for lameness. The adult cow health events score was calculated by giving points to each farm that had ≤ 32 health events per 100 cow years, ≤ 0 dead cows (mortality) per 100 cow years, $< 1.4\%$ of cows scored as being over-conditioned, $< 1.7\%$ of cows scored as being under-conditioned, $< 2.5\%$ of cows scored as being lame, $< 13.7\%$ of cows scored as having poor hygiene and $\leq 2.5\%$ of cows scored as having hock lesions (Table 3.1). Thresholds to assign points for the best performing herds were based on the 25^{th} percentiles for each category. Based on the health events percentiles, a single point was assigned to each farm if a cow had any of the evaluated diseases (mastitis, milk fever, ketosis, diarrhea, metritis, respiratory disease, displaced abomasum, foot infection, procedures or treatments) or a combination, during either the 120 or 60 day farmer reporting period. Health events were standardized to cases per 100 cow years. Mortality was recorded by famers and was defined as any cow that died on the farm for either 120 or 60 days during the farmer reporting period. Mortality was then standardized to cases per 100 cow years.

The calf management score was created by assigning a single point for calf health and management practices that can positively impact animal welfare (Table 3.2 & 3.3). The 25^{th} percentile for respiratory disease prevalence and the 50^{th} percentile for diarrhea prevalence were used as thresholds to assign points for each herd (Table 3.2). The 50^{th} percentile was chosen,

because greater than 50% of herds had zero calves scored with diarrhea. For calf health thresholds of 0% were used for calves observed with symptoms of respiratory disease and diarrhea (Table 3.2). For each farm, a point was assigned for each of the follow: 1) farms with zero calves scored as having diarrhea, 2) farms with zero calves scored as having respiratory disease, 3) housing calves in an area in which they were able to turn around, 4) disinfecting neonatal navels, 5) feeding ≥ 4 liters of milk to preweaned calves, 6) feeding grain to preweaned calves, 7) using pain relief for dehorning (local anesthetic, NSAID or sedation), and 8) using less painful methods to dehorn (such as chemical paste and hot iron). Based on the importance of colostrum to calf health, an additional half point was given for each of the following practices: 1) fed ≥ 4 liters of colostrum, 2) fed the first colostrum within 6 hours from the time of birth, 3) fed colostrum only thru nursing, and 4) fed between 4 and 6 liters of milk to preweaned calves. Lastly, a ¼ point was given to farmers that used a homeopathic pain reliever for dehorning as the efficacy of these products have not been studied. Farms that received a score of ≥ 6 points were categorized as having the best calf health and management.

3.3.3 Statistical Procedures

All statistics were completed using SAS 9.3 (SAS Institute, 2011). Descriptive statistics were used to check for missing data or entry errors. PROC FREQ was used for all categorical variables and PROC UNIVARIATE for all continuous variables (SAS Institute, 2011). Statistical significance was defined as $P \leq 0.05$.

Herd size consisted of three levels: 1) small (20 – 99 total adult cows), 2) medium (100-200 total adult cows), and 3) Large (> 200 total adult cows). The primary age of the herd was divided into three levels: 1) few older cows (≤ 34% of cows were in third or greater lactation), 2) some older cows (35- 49 % of cows in third or greater lactation), 3) many older cows (> 49% of

cows third or greater lactation). The season of visit was categorized as spring, summer, autumn or winter. The predominant breed of each herd consisted of three levels 1) Holstein (> 50% of the herd was Holstein), 2) Jersey (> 50% of the herd was Jersey), and 3) Other breed (> 50% of the herd was any breed other than Holstein or Jersey and included crossbred cattle). Rolling herd average (RHA) had three levels: 1) greatest (> 8960 kg/cow/year), 2) moderate (5675 – 8960 kg/cow/year), and 3) least (< 5675 kg/cow/year). The number of years dairying experience consisted of three levels: 1) few years (< 15 years), 2) some years (15 – 31 years) and 3) many years (> 31 years). Pre-weaned calf housing had two levels: 1) group housed (multi-animal pen, freestall, pasture or drylot) and 2) individually housed (tied in a barn, individual pen or hutch). Housing of lactating cows consisted of three levels: 1) multi-animal pen or freestall, 2) pasture or drylot and 3) tie stall or stanchion. For farms that reported multiple housing areas throughout the year, the housing used during the time of the visit was used for analysis. The number of hours spent outdoors 60 days prior to the study visit was divided into three categories: 1) none (zero hours), 2) some (1 – 19 hours), and 3) many (20 – 24 hours). Routine veterinary visits were calculated by the number of visits per 100 cows per year (Richert et al., 2013) and had three levels: 1) none (no routine vet visits), 2) some (1 – 20 visits/100 cows/year), and 3) many (> 20 visits/100 cows/year). The distribution for adult cow health score (Table 3.1), calf health (Tables 3.2) and management score (Table 3.3) was calculated by univariate analysis and percentiles were used to create thresholds for the best performing herds versus other herds.

All explanatory variables were screened for unconditional associations with adult cow health scores and calf health and management scores. Biologically relevant explanatory variables were tested for possible associations with the scores using Chi-square and Fishers exact (if frequencies were less than 5) tests (PROC FREQ) and all variables found to be

unconditionally associated ($P < 0.20$) were offered for the multivariate model. Furthermore, forward and backward selection procedures were used on the unconditionally associated variables to create the final model. The impact of each variable on the estimates of other explanatory variables were used to test for confounding and interactions (Dohoo et al., 2003).

Final models were then tested for associations among each score (adult cow health, calf health and calf management), design variables and explanatory variables using logistic regression (PROC LOGISTIC). In addition, associations between adult cow health scores and calf health and management scores were tested using Chi-square (PROC FREQ). Interactions were tested for variables that had ≥ 5 observations and none were found to be significant.

3.4 RESULTS

3.4.1 General Farm and Score Characteristics

A total of 241 farms were used for the analysis of adult cow health (Table 3.1) and calf health and management (Table 3.3). Fifty one herds were removed due to missing criteria for either of the two scores. The top 25% of farms for adult cow health had a score ≥ 3 out of 6 points and the top 32% of farms for calf health and management had a score of ≥ 6 out of 8.5 points.

Based on the criteria used to define adult cow health, a total of 69 (24%) of farms received one point for health events, 149 (52%) farms received one point for mortality, 74 (25%) farms received one point over-conditioned cows, 71 (24%) farms for under-conditioned cows, 78 (27%) farms for lame cows, 68 (24%) farms for dirty cows and 71 (24%) farms for having cows with hock lesions. Therefore, herds were distributed as point values for adult cow health: 0 (n = 41, 15%), 1 (n = 78, 28%), 2 (n = 64, 23%), 3 (n = 63, 22%), 4 (n = 23, 8%), 5 (n = 8, 3%), 6 (n

= 3, 1%). Herds with ≥ 3 points were categorized as having "the best adult cow health" and herds with < 3 points were categorized as "other adult cow health".

Based on the criteria used to define calf health and management categories the frequency of calf health and management score was: 1.5 (n = 2, 0.8%), 2 (n = 2, 0.8%), 2.5 (n = 9, 3.7%), 3 (n = 7, 2.9%), 3.5 (n = 24, 10.0%), 4 (n = 18, 7.5%), 4.5 (n = 39, 16.2%), 5 (n = 21, 8.7%), 5.5 (n = 43, 17.8%), 6 (n = 23, 9.5%), 6.5 (n = 31, 12.9%), 7 (n = 5, 2.1%), 7.5 (n = 13, 5.4%), 8 (n = 3, 1.2%), 8.5 (n = 1, 0.41%). Herds with ≥ 6 points were categorized as having "the best calf health and management" and herds with < 6 points were categorized as having "other calf health and management".

3.4.2 Adult Cow Health Score

Univariate relationships between explanatory variables and cow health score categories were determined for 83 (34%) farms with the best cow health score (score ≥ 3) and 158 (66%) herds with other cow health (score < 3). The following explanatory variables were not associated with cow health scores ($P > 0.20$): 1) primary age of herd, 2) season of visit, 3) number of years dairying and 4) routine use of veterinarians and were not eligible for entry in the multivariate modeling process. After multivariate analysis, the final model for adult cow health score category consisted of the design variables (graze category, herd size and state), breed, rolling herd average, adult cow housing and number of hours spent outside. The AIC of the final multivariate model was 262, with a Fishers X^2 of 74 and 14 degrees of freedom.

Explanatory variables were tested to determine the likelihood of being categorized as having the best adult cow health (Table 3.4). Conventional grazing herds were less likely to be categorized as having the best adult cow health as compared to ORG herds ($P = 0.002$). Conventional grazing herds received fewer points for each criteria of the adult cow health score

compared to ORG herds (Table 3.7). Herds in New York (59%) were 7 times more likely to be categorized as having the best adult cow health as compared to WI (16%; $P < 0.001$). Herds in OR (53%) were 14 times more likely to be categorized as having the best adult cow health score as compared to WI (16%; $P < 0.001$). Herds in WI were less likely to receive a point for having ≤ 32 health events per 100 cow years, the proportion of cows being scored as under-conditioned and the proportion of cows being scored with poor hygiene compared to herd in NY and OR (Table 3.8). No significant association was found among herd size categories ($P = 0.814$), predominant breed categories ($P = 0.175$), rolling herd averages ($P = 0.839$) or hours spent outside ($P = 0.460$) and adult cow health score category. Farms that primarily housed adult cows in multi-animal pens or freestalls were 4 times more likely to have the best adult cow health score as compared to farms that primarily housed adult cows in tie stalls or stanchions ($P = 0.034$). Farmers that primarily housed adult cows in tie stalls or stanchions received fewer points for the proportion of cows being scored as over-conditioned, under-condition, having poor hygiene, hock lesions and being lame compared to farmers that primarily housed their adult cows in multi-animal pens or freestalls (Table 3.9).

3.4.3 Calf Health and Management Score

Univariate relationships between explanatory variables and calf health and management score categories were determined for 73 (30%) farms with the best calf health and management score (score ≥ 6) and 168 (70%) farms with other calf health and management scores (score < 6). The following explanatory variables were not associated with calf health and management score category ($P > 0.20$): 1) age of the herd, 2) season of visit, 3) predominant breed, 4) rolling herd average and 5) routine veterinary visits and were not eligible for entry in the multivariate modeling process. After multivariate analysis the final model for calf health and management

score category consisted of the design variables (graze category, herd size and state) and the years of dairying experience and calf housing. The AIC of the final multivariate model was 295, with a Fishers X^2 of 24 and 11 degrees of freedom.

The final model was tested to determine the likelihood of being categorized as having the best calf health and management (Table 3.5). No association was observed among the calf health and management score and graze category (P = 0.101; Table 3.5 and Table 3.10). No significant association was found between herds categorized as having the best calf health and management and state (P = 0.861), herd size (P = 0.280) and years of dairying experience (P = 0.094; Table 3.5). Farms that primarily housed calves in individual pens or hutches were 4.5 times more likely to be categorized as having the best calf health and management compared to farms that tied calves in a barn for housing (P = 0.028; Table 3.5). Farms that primarily housed calves in multi-animal pens or freestalls were 3.7 times more likely to be categorized as having the best calf health and welfare as compared to farms that tied calves in a barn for housing (P = 0.028; Table 3.5). Farmers that primarily tied their calves in a barn for primary housing received the least amount of points for having zero calves with respiratory disease, disinfecting calf navels, housing calves in an area that allows them to turn around, feeding pre-weaned calves starter and using the least painful methods to dehorn compared to farmers that primarily housed their calves in individual pens, hutches, multi-animal pens or freestalls (Table 3.11).

3.4.5 Likelihood of being categorized as being the best for multiple scores

No association was observed among the calf health and management score categories and the adult cow health events score categories (P = 0.066; Table 3.6).

3.5 DISCUSSION

Consumer concern about animal welfare has increased the need for scientific methods to measure dairy cattle wellbeing. Many management practices can directly impact an animal's wellbeing, such as nutrition (Wells et al., 1996; Weaver et al., 2000; Roche et al., 2009), painful procedures (Faulkner and Weary, 2000; Vasseur et al., 2010), neonatal care (Vasseur et al., 2010), and housing (National Farm Animal Care Council, 2009). The main objective of this study was to identify and quantify factors that affect dairy cattle welfare (such as prevalence of disease, management practices and mortality) and to create a method to assess these factors on organic and similarly sized conventional farms. There are no other studies in the United States comparing welfare indicators among conventional and organic farms. In the United States welfare assessment and audit programs are voluntary and these programs vary in the measures used to assess welfare (Chapter 1 & 2). While this study included a number of potential objective measures of dairy animal welfare, other practices, such as tail docking, methods of euthanasia and procedures used for livestock handling were not included and should be considered in future studies. For example, we could not include tail docking as ORG herds in the United States are not allowed to dock tails and this variable would have thus been a potentially confounding variable. The data collected in this study allowed for quantification and indication of welfare practices on 241 dairy farms across Wisconsin, Oregon and New York, including organic and similarly sized conventional dairies. In addition, this study provides a representation of small organic and conventional dairies across three important dairy states.

Management practices are known to vary among ORG and CON dairy farms, although not much is known on how these differences influence dairy cattle welfare. Stiglbauer et al. (2013) reported general management characteristics using the same study population. The

authors indicated a trend for the presence of young cows on CON farms as compared to older cows on ORG farms. A farm that has many young animals does not necessarily indicate poor welfare, as culling decisions are complex and a younger herd can simply be an indicator of having many young replacement heifers and preferring to keep those animals rather than sell them. In the current study, the primary age of animals in these herds did not influence either of the scores. In addition, Stiglbauer et al. (2013) reported no difference was observed among the graze categories and the number of years spent dairying. The current study found that the years of dairying experience did not influence welfare. Feeding practices are known to vary between organic and conventional farms (Stiglbauer et al., 2013). Stiglbauer et al. (2013) reported that ORG herds fed approximately 45% less grain to adult cattle as compared to CON farms. In contrast, our study indicated that ORG herds were more likely to feed grain to preweaned calves as compared to CON farms (Chapter 2). However, this did not influence the calf health and management score as no association was observed among the score and graze categories.

It is reasonable to assume that regular use of veterinarians may be associated with welfare of dairy animals. Using the same population Richert et al. (2013), looked at the use of veterinarians on ORG, CONGR and CONNG farms. No veterinary visits were reported by 50 (25%) farmers and 682 visits were reported by 149 (75%) farmers during the observation period. Of the 682 visits, 321 were routinely scheduled visits. In the current study the routine use of veterinarians was not found to be associated with either welfare score.

The adult cow health events score was created to objectively measure and categorize each farms overall cow health. Indicators were selected to reflect management decisions that are known to influence animal welfare. Each score, such as lameness (Hemsworth et al., 1995), presence of hock lesions (Rutherford et al., 2008), over-conditioned and under-conditioned body

scores (Roche et al., 2009), poor hygiene (Sant'Anna and da Costa, 2011), morbidity and mortality (Thomsen et al., 2006) have previously been associated with welfare.

Injuries such as lameness and hock lesions inflict pain and thus reduce the animal's welfare according to the third freedom; freedom from pain, injury and disease (Farm Animal Welfare Council, 1993). In addition to lameness causing pain, lameness may reduce feed intake and thus reduce body condition (Hemsworth et al., 1995). In the current study lameness was included in the adult cow health events score and farms that had < 2.5% of cows scored lame (score 3 & 4) received one point thus making up one seventh of the overall score. Welfare programs such as the American Humane Association (2012) and the National Dairy Farm Program (2012) require that 95% cows must have a lameness score ≤ 2. In the current study, the top 25% of herds would have met this requirement. With the use of this threshold farmers are able to determine how their farm compares to others for the prevalence of lameness.

Hock lesions can be used as a measure of the comfort or discomfort of the lying surface based on the amount of damage (Rutherford et al., 2008). The American Humane Association (2012) requires that no more than 2% of the herd have a hock lesion score of 2 & 3 (on a 4-point scale) and the National Dairy Farm Program (2012) requires that no more than 5% have a hock lesion score of 2 & 3 (on a 3-point scale). In this study, a threshold was developed and farms that had < 2.6% of cows scored with hock lesions (score 2 & 3) received one point for adult cow health score. Thus the top 25% of herds had a proportion of cows scored with hock lesions that were between the two welfare program requirements. With the use of hock lesions as part of the adult cow health score farms can assess the overall percentage of cows with hock lesions and compare their results in relation to the thresholds developed. In addition farmers will be able to

judge, based on these thresholds, whether the cows lying surface is sufficient or requires improvement.

Freedom from hunger, thirst and malnutrition is the first of the five freedoms (Farm Animal Welfare Council, 1993). Not only does the provision of adequate diets impact an animal's wellbeing, but it is also vital to maintain health and productivity (Burkholder, 2000). Body condition is commonly measured as a means of assessing the proportion of body fat on cattle (Roche et al., 2009). A thin animal may have poor welfare due to disease or nutritional mismanagement, where as an over-conditioned animal is at risk for metabolic diseases. Therefore body condition can be indicative of compromised welfare (Roche et al., 2009). For the adult cow health score, a threshold of < 1.4% of cows scored as being over-conditioned (BCS score > 4.0) was used to give farms one point. In addition farms that have < 1.8% of cows scored as under-conditioned received one point for the adult cow health score. With these thresholds, farmers can decide whether there is a need for attention for nutrition on their farm.

Poor animal hygiene is considered a welfare issue and can be affected by disease, climatic conditions and animal behavior (Sant'Anna and da Costa, 2011). Poor hygiene has been associated with increased risk of disease, such as mastitis (Schreiner and Ruegg, 2003). Included in the adult cow health score is udder hygiene. Farms that had < 13.7% of cows scored as having poor udder hygiene (UHS 3 & 4) received one point. Farmers that did not fall within this threshold should put effort towards areas which might be the cause of excessively dirty cows, such as housing and alleyways in order to improve overall dairy cattle wellbeing.

Excess morbidity and mortality are clearly associated with undesirable outcomes that may result in pain or suffering and are obvious indicators of welfare of dairy animals (Thomsen et al., 2006; Ahlman et al., 2011). Dairy cattle live in herds and the occurrence of disease is not

uncommon but is influenced by many farm management characteristics. Therefore, included in the adult cow health score were cases of disease, other health events and mortality. Farms that had ≤ 32 cases of sick cows per 100 cow years received one point and farms with zero cow deaths per 100 cow years received one point. Health events included: mastitis, milk fever, metritis, ketosis, diarrhea, displaced abomasum, foot problems and other possible illnesses. These variables are very similar to those reported by National Animal Health Monitoring System (2007a). In our study, the mean and median cases of health events per 100 cow years was 80 and 61, respectively. On some farms a large number of health events per 100 cow years may have been caused by farmers who reported trimming hooves every few weeks on numerous cows and a few farmers who had many cases of disease. However, the median results of our study are similar to the 58% of cows with health events reported by the National Animal Health Monitoring System (2007a). Although the maximum number of cow deaths was 35 per 100 cow years, the mean number of cow deaths was less than the 5.7% of cow deaths reported by the National Animal Health Monitoring System (2007a). The maximum number of cow deaths per 100 cow years was possibly caused by a few small farms that reported having a number of cows die from difficult calvings, disease and injury.

With the use of this adult cow health score, farmers will be able to benchmark their farm against others for animal welfare. In addition, with the use of thresholds for each area of the adult cow health score farmers will be able to pin point areas in need of attention in order to improve the farm's overall welfare.

In the population of small farms included in this study, CONGR farms were less likely to have the best adult cow health compared to ORG herds. This difference may be, because CONGR farms had less proportion of farms receive a single point for each criterion of the adult

cow health score as compared to ORG farms (Table 3.7). Farms in NY and OR may have been more likely to be categorized as having the best cow health compared to WI, as farms in WI were more likely to surpass the thresholds for health events, proportion of cows scored as being under-conditioned and proportion of cows scored with poor hygiene (Table 3.8). It is possible that observer bias contributed to this finding. Farmers that primarily house their adult cattle in multi-animal pens or freestalls were more likely to be categorized as having the best adult cow health as more points were received for body condition, hygiene, hock lesions and lameness compared to farmers who housed their adult cattle in tie stalls or stanchions (Table 3.9).

Calves are the most vulnerable animals on a dairy farm and a number of management practices as well as calf health have been shown to impact their welfare, such as colostrum care (Weaver et al., 2000; Vasseur et al., 2010), dipping of calf navels (Vasseur et al., 2010), amount of milk fed , calf housing (National Farm Animal Care Council, 2009), feeding of starter to preweaned calves (Jasper et al., 2008), use of pain relief and dehorning (Faulkner and Weary, 2000)). In the study reported herein, calf health and several of these management characteristics were scored and the scores were combined to create a calf health and management score that can be used as to assess welfare.

Calf health, such as disease, injury, morbidity and mortality can be used as a method to assess the welfare of calves (Stull and Reynolds, 2008). In previous studies, the most common diseases in dairy calves include: diarrhea, respiratory problems and salmonella (Frank and Kaneene, 1993; Losinger et al., 1995; Svensson et al., 2003). According to the National Animal Health Monitoring System (2007a), scours, diarrhea, or other digestive problems accounted for 56.5% of preweaned heifer mortality, while 22.5% of deaths were caused by respiratory disease. In addition to the mortality, 23.9% of preweaned heifers had diarrhea and 12.4% had respiratory

disease during the 12 months prior to the study. In general, calves in this study population had very good health. Greater than 40% of our study herds had zero calves scored as having diarrhea and respiratory disease. An average of 6% of preweaned calves with diarrhea and 11% with respiratory disease were observed during a single visit (Table 3.2).

Housing can have a large impact on calf wellbeing. According to the Canadian Dairy Code of Practice (National Farm Animal Care Council, 2009) housing should provide comfort, insulation, warmth, dryness and traction, while allowing for calves to turn around, lie down, stand up, adopt normal resting postures and have visual contact with other calves. In the current study, 35 (15%) farms had calves housed in areas which did not allow for the calf to turn around. The primary housing for calves were: multi-animal pen or freestall (18%), tied in a barn (13%), individual pen or hutch (63%), and pasture or drylot (6%). Although, 13% of farms primarily had calves tied in a barn not all of these farms had calves that were unable to turn around at the time of the visit. However, farms that primarily tied calves up in a barn were less likely to be categorized as having the best calf health and management because these farms received the least amount of points for calves without respiratory disease, disinfection of calf navels and the ability for calves to turn around (Table 3.10) Not allowing young animals the freedom of movement can negatively impact welfare as it restricts their ability to exercise and socialize, both of which are important to young calf behavior.

Receiving timely and adequate volumes of colostrum is vital to ensure health and wellbeing of calves. Recommended amounts of colostrum are a minimum of 2 liters for small calves and a minimum of 4 liters for normal to large calves (Weaver et al., 2000; Vasseur et al., 2010) and needs to be given by 6 hours after birth for optimal absorption. For the calf management score farms that fed $\geq$ 4 liters of colostrum received a 1/2 point whereas farms that

fed < 4 liters did not receive a point. In the current study, 232 (96%) and 9 (4%) farmers reported feeding < 4 liters or ≥ 4 liters, respectively. One farmer reported not feeding any colostrum. According to the National Animal Health Monitoring System (2007b) 63.5% of farms that hand-fed colostrum, 69% fed less than 4 quarts (3.79 liters) of colostrum, compared to the 31% that fed 4 quarts (3.79 liters) or more of colostrum. Times for the first feeding of colostrum were reported by farmers as ≤ 6 hours and > 6 hours or colostrum only received through the dam for 187 (78%) and 54 (22%) farmers, respectively. This percentage of farmers that gave colostrum within 6 hours after birth was less than reported by Vasseur et al. (2010), who reported 94.8% of farmers surveyed in Quebec, Canada gave the first colostrum within 6 hours. Thus, indicating many calves in this study population are not receiving an adequate amount of colostrum or in the appropriate amount of time. Without passive immunity calves are at a greater risk for morbidity and mortality.

Feeding starter or such solid food to preweaned calves is a recommended practice to aid in weaning and rumen development. Farmers that reported feeding calves starter received one point towards the calf management score. In the current study, 108 (45%) of farmers reported not feeding any starter to preweaned calves. Without feeding calves starter there is an increased risk for hunger, especially in limit milk fed calves. In addition, feeding solid food can help avoid decreased feed intake, weight loss and excessive vocalization during weaning (Jasper et al., 2008; Weary et al., 2008; Vasseur et al., 2010).

It is highly recommended that all dairy farmers administer pain relief to all animals during painful procedures to ensure freedom from pain. Calves should be dehorned prior to 8 weeks of age so less painful techniques can be utilized. Points were assigned to farmers that reported using any pain relief while dehorning and to farmers that reported using less painful

methods to dehorn such as chemical paste and hot iron. In the current study, the scoop, gouge or cut out method was used by 18% of farmers to dehorn calves and (72%) farmers reported not using any pain relief during dehorning. Of the farmers that reported using pain relief the majority reported using local anesthetics (52%), followed by sedation (22%) and other (22%) and lastly NSAIDs (4%). In addition, 18% of farmers reported using a more painful method to dehorn calves (scoop, gouge or cut out method). These areas dehorning and pain management during painful procedures require attention in order to improve calf wellbeing.

With this score including areas of: colostral management, neonatal care, calf housing, pain relief for dehorning, dehorning methods and preweaned calf care farmers will be able to see what calf management areas require attention and need to be changed in order to improve their dairy's welfare. No current studies exist that created a score to assess management practices and their associations between ORG and CON farms. No association was found among the calf health and management score and graze categories. Although CONNG had the least proportion, only 27% of farmers overall reported the use of pain relief. In addition, only 57% of farms overall in this study reported feeding pre-weaned calves starter. These results indicate areas that require attention to improve calf wellbeing.

3.6 CONCLUSION

Two objective scores were created to develop measureable indicators to assess welfare of both calves and adult cows on an individual farm basis. Scores were used to categorize herds with the best welfare as compared to other herds. No association was observed among graze category and the calf health and management score. However, CONGR farms were less likely to have the best adult cow health score as compared to ORG farms. Wisconsin had the least proportion of farms with points for health events, under-conditioned cows and poor hygiene as

compared to OR and NY farms. Farms that primarily housed their calves in individual pens, hutches, multi-animal pens or freestalls were more likely to be categorized as having the best calf health and management as compared to farms that tied calves in a barn for housing. This study is unique as it compares ORG and CON dairy farms to indicators of dairy cattle wellbeing.

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Table 3. 2 Herd-level descriptive statistics of variables that created the adult cow health score (n = 241)[1]

Variables	Thresholds	Mean	SD	Min	10th	25th	Median	75th	90th	Max
Health events[2]	≤ 32.0	79.95	0.75	0.00	14.87	32.88	60.83	107.35	159.82	553.03
Mortality[3]	≤ 0.0	4.00	0.06	0.00	0.00	0.00	0.00	7.07	11.70	35.37
Over Conditioned[4]	< 1.4%	9.67%	10.06	0.00%	0.00%	1.56%	6.67%	15.00%	23.33%	50.00%
Under Conditioned[5]	< 1.7%	9.09%	11.03	0.00%	0.00%	1.75%	6.33%	12.86%	21.05%	88.64%
Lameness[6]	< 2.5%	8.43%	7.59	0.00%	0.00%	2.86%	7.14%	12.50%	18.18%	53.57%
Dirty Udder Hygiene[7]	< 13.7%	33.37%	23.24	0.00%	3.85%	12.68%	31.03%	52.17%	66.67%	93.44%
Hock Lesions[8]	< 2.5%	18.87%	21.06	0.00%	0.00%	2.44%	10.45%	28.81%	53.52%	95.45%

[1]Percentiles of health events, mortality, body condition variables, udder hygiene variables, lameness and hock lesions to show the cutoffs used to create the adult cow health score.

[2] Total health events per 100 cow years. The threshold for least sick cows of ≤ 32.0 was based on the 25th percentile. Health events included: mastitis, milk fever, metritis, lameness, displace abomasum, ketosis, respiratory and foot infections.

[3] Total dead cows per 100 cow years. The threshold for least cow deaths of ≤ 0.0 was based on the 50th percentile.

[4] Based on body condition > 4.0, the threshold for least over-conditioned cows of < 1.4% was based on the 25th percentile.

[5] Based on body condition ≤ 2.25 the threshold for least under-conditioned cows of < 1.7% was based on the 25th percentile.

[6] Based on lameness scores 3 & 4 the threshold for least lame cows of < 2.5% was based on the 25th percentile.

[7] Based on udder hygiene score 3 & 4 the threshold for least dirty cows of < 13.7% was based on the 25th percentile.

[8] Based on hock scores 2 & 3 the threshold for least cows with hock lesions of < 2.5% was based on the 25th percentile.

Table 3. 3 Herd-level descriptive statistics of pre-weaned calves scored as having diarrhea or respiratory disease (n = 241)[1]

Variables	Unit of Measurement	Threshold	Mean	St. Deviation	Min	10th	25th	Median	75th	90th	Max
Respiratory Disease[2]	% of calves	≤ 0%	11.23%	0.18	0.00%	0.00%	0.00%	2.00%	16.22%	33.33%	100.00%
Diarrhea[3]	% of calves	≤ 0%	6.06%	0.14	0.00%	0.00%	0.00%	0.00%	5.26%	20.00%	100.00%

[1]Percentiles of calves with respiratory disease and diarrhea to show the cutoffs used to create the calf health score.

[2] Based on the respiratory score (calves scored with either, nasal discharge, ocular discharge, droopy ears or cough) the threshold for least calves scored as having respiratory disease of ≤ 0% was based on the 25th percentile.

[3] Based on calves scored as having diarrhea the threshold for least calves scored of ≤ 0% was based on the 50th percentile.

Table 3. 4 Descriptive statistics of variables that created the calf health and management score

Variables	Outcome	Frequency (%)
At least one calf unable to turn around	Unable to Turn Around	35 (15%)
	Able to Turn Around	206 (85%)
Dipping of neonatal navels	No Dipping of Navels	96 (40%)
	Dipping of Navels	145 (60%)
Feeding preweaned calves starter	No Starter Fed	108 (45%)
	Starter Fed	133 (55%)
Use of any pain relief while dehorning	No Pain Relief Used	174 (72%)
	Local, NSAID or sedation	54 (23%)
	Homeopathic	13 (5%)
Amount of milk fed	< 4 liters	115 (48%)
	≥ 4 and < 6 liters	66 (27%)
	≥ 6 liters	60 (25%)
Painful Method Used to Dehorn	Scoop, Gouge or Cut Out	44 (18%)
	Other Less Painful Methods	197 (82%)
Time of First Colostrum	>6 hours or Received Via the Dam	34 (14%)
	≤ 6 hours After Birth	207 (86%)
Amount of Colostrum	< 4 Liters	228 (95%)
	≥ 4 Liters	13 (5%)
Calves with Diarrhea	> 0 calves with symptom	82 (34%)
	= 0 calves with symptom	159 (66%)
Calves with Respiratory	> 0 calves with symptom	123 (51%)
	= 0 calves with symptom	118 (49%)

Table 3. 5 Associations between graze category, state and herd size, cow housing and hours spent outside with adult cow health scores

	Cow Health[1]					
Categories	Best Herds (%)[2]	Other Herds (%)[3]	Estimate (SE)	Odds Ratio[4]	95% CI	P-value
Intercept			-1.26			
Graze Category[5]	83	158				0.002
ORG	68 (43.6%)	88 (56.4%)	Reference			
CONGR	3 (10.0%)	27 (90.0%)	-1.37	0.07	(0.02 , 0.33)[12]	
CONNG	12 (21.8%)	43 (78.2%)	0.11			
State[6]	83	158				<0.001
WI	19 (16.2%)	98 (83.8%)	Reference			
NY	47 (59.1%)	45 (48.9%)	0.38	6.53	(3.16 , 13.49)[13]	
OR	17 (53.1%)	15 (46.9%)	1.12	13.74	(3.85 , 49.04)[14]	
Herd Size[7]	83	158				0.814
Small	57 (31.7%)	123 (68.3%)	Reference			
Medium	14 (40.0%)	21 (60.0%)	-0.12			
Large	12 (46.2%)	14 (53.8%)	-0.05			
Breed[8]	83	158				0.175
Other	35 (53.0%)	31 (47.0%)	Reference			
Holstein	41 (26.3%)	115 (73.7%)	-0.08			
Jersey	7 (36.8%)	12 (63.2%)	-0.45			
Rolling Herd Average[9]	81	158				0.839
Medium	45 (35.7%)	81 (64.3%)	Reference			
Low	22 (41.5%)	31 (58.5%)	0.04			
High	14 (23.3%)	46 (76.7%)	0.10			
Cow Housing[10]	83	158				0.034
Tie Stall or Stanchion	11 (18.0%)	50 (82.0%)	Reference			
Multi-animal Pen or Freestall	23 (41.8%)	32 (58.2%)	0.79	4.20	(1.39 , 12.67)[15]	
Pasture or Drylot	49 (39.2%)	76 (60.8%)	-0.14			
Hours Spent Outside[11]	83	158				0.460
Some Hours	26 (25.7%)	75 (74.3%)	Reference			
None	20 (35.1%)	37 (64.9%)	0.30			
Many Hours	37 (44.6%)	46 (55.4%)	-0.09			

[1] Adult cow health scores consisted of a single point for each category where a farm had ≤ 32 health events per 100 cow years, ≤ 0 cow deaths per 100 cow years, < 1.4% of cows scored as being over-conditioned (BCS > 4), < 1.7% under-conditioned (BCS ≤ 2.25), < 13.7% dirty (Udder Hygiene Score 3 & 4), < 2.5% having hock lesions (Hock Score 2 & 3), or < 2.5% lameness.
[2] There were 83 herds categorized as having the best adult cow health (score ≥ 3).
[3] There were 158 herds categorized as having other adult cow health (score < 3).
[4] Odds Ratios are only reported for significant variables.
[5] Graze Category was defined as ORG (n = 156), CONGR (n = 30), CONNG (n = 55).
[6] State was defined as WI (n = 117), NY (n = 92), OR (n = 32).
[7] Herd Size was defined as Small (< 100 Cows, n = 180), Medium (100-200 Cows, n = 35), Large (> 200 Cows, n = 26).
[8] Breed was defined as Holstein (n = 156), Jersey (n = 19), Other (n = 66).
[9] Rolling Herd Average was defined as Medium (n = 126), Low (n = 53), High (n = 60).
[10]Cow Housing was defined as Pasture or Drylot (n = 125), Multi-animal Pen or Freestall (n = 55), Tie Stall or Stanchion (n = 61),
[11] Hours Spent Outdoors was defined as None (n = 57), Some (1 – 19 hours, n = 101) and Many (> 19 hours, n = 83).
[12] Conventional graze farms were less likely to be categorized as having the best adult cow health score as compared to ORG farms.
[13] New York farms were 7 times more likely to be categorized as having the best adult cow health score as compared to WI farms.
[14] Oregon farms were 14 times more likely to be categorized as having the best adult cow health score as compared to WI farms.
[15] Farms that housed their adult cows in Multi-animal Pens or Freestalls were 4 times more likely to be categorized as having the best adult cow health score as compared to farms that housed their adult cows in Tie Stalls or Stanchions.

Table 3. 6 Associations between graze category, state, herd size, number of years dairying and calf housing with calf health and management scores

Categories	Calf Health & Management Score[1]					
	Best Health & Management (%)[2]	Other (%)[3]	Estimate (SE)	Odds Ratio[4]	95% CI	P-value
Intercept			-1.88			
Graze Category[5]	73	168				0.101
ORG	53 (34.0%)	103 (66.0%)	Reference			
CONGR	10 (33.3%)	20 (66.7%)	0.05			
CONNG	10 (18.2%)	45 (81.8%)	-0.46			
State [6]	73	168				0.861
WI	39 (33.3%)	78 (66.7%)	Reference			
NY	25 (27.2%)	67 (72.8%)	-0.12			
OR	9 (28.1%)	23 (71.9%)	0.07			
Herd Size[7]	73	168				0.280
Small	60 (33.3%)	120 (66.7%)	Reference			
Medium	8 (22.9%)	27 (77.1%)	-0.06			
Large	5 (19.2%)	21 (80.8%)	-0.39			
Years Dairying[8]	73	168				0.094
Some years	35 (30.2%)	81 (69.8%)	Reference			
Many years	13 (20.1%)	49 (79.0%)	-0.47			
Few years	25 (39.7%)	38 (60.3%)	0.46			
Calf Housing[9]	73	168				0.028
Tied in a barn	4 (12.5%)	28 (87.5%)	Reference			
Individual pen or hutch	50 (33.8%)	98 (66.2%)	0.82	4.50	(1.40 , 14.51)[10]	
Multi-animal pen or freestall	17 (36.2%)	30 (63.8%)	0.62	3.71	(1.08 , 12.74)[11]	
Pasture or Drylot	2 (15.4%)	11 (84.6%)	-0.75			

[1]Calf health and management score consisted of one point for each management area that may positively impacts the wellbeing of calves including: housing calves in an area in which they are able to turn around, dipping neonate navels, feeding ≥ 6 liters of milk to preweaned calves, feeding grain to preweaned calves, using pain relief (local, NSAID, sedation) during dehorning, and using less painful method to dehorn calves, farms that had > 0 calves scored with respiratory disease and farms that had > 0 calves scored as having diarrhea. Additionally a ½ point was given to farmers that reported nursing for colostrum as the sole source for colostrum,

feeding ≥ 4 liters of colostrum, feeding the first colostrum within 6 hours from the time of birth and to farmers that fed between 4 and 6 liters of milk to preweaned calves. An ¼ was given to farmers that used homeopathic pain relief while dehorning.

[2] There were 76 herds categorized as having the best calf health and management (a score ≥ 6).

[3] There were 168 herds categorized as having other calf health and management (a score < 6).

[4] Odds Ratios are only reported for significant variables.

[5] Graze Category was defined as ORG (n = 156), CONGR (n = 30), CONNG (n = 55).

[6] State was defined as WI (n = 117), NY (n = 92), OR (n = 32).

[7] Herd Size was defined as Small (< 100 Cows, n = 180), Medium (100-200 Cows, n = 35), Large (> 200 Cows, n = 26).

[8] Number of Years Dairying was defined as Some Years (15 – 31 years dairying, n = 116), Few Years (< 15 years dairying, n = 63), Many Years (> 31 years dairying, n = 62).

[9] Calf housing was defined as Tied in a barn (n = 32), Individual pen or hutch (n = 148), Multi-animal pen or freestall (n = 47), Pasture or drylot (n = 13).

[10] Farms that primarily housed calves in individual pens or hutches were 4.5 times more likely to be categorized as having the best calf health and management compared to farms that primarily tied calves in a barn for housing.

[11] Farms that primarily housed calves in multi-animal pens or freestalls were 3.7 times more likely to be categorized as having the best calf health and management compared to farms that primarily tied calves in a barn for housing.

Table 3. 7 Associations among calf health and management score and adult cow health events score

	Management Score[1]		
Categories	Best Herds (%)[2]	Other Herds (%)[3]	P-value
Intercept			
Adult Cow Health Score[4]	76	165	0.066
Best Herds	5 (16%)	26 (84%)	
Other Herds	68 (32%)	142 (68%)	

[1] Calf management score consisted of one point for each management area that may positively impact the wellbeing of calves including: housing calves in an area in which they are able to turn around, dipping neonate navels, feeding ≥ 6 liters of milk to preweaned calves, feeding grain to preweaned calves, using pain relief (local, NSAID, sedation) during dehorning, and using less painful method to dehorn calves, farms that had > 0 calves scored with respiratory disease and farms that had > 0 calves scored as having diarrhea. Additionally a ½ point was given to farmers that reported nursing for colostrum as the sole source for colostrum, feeding ≥ 4 liters of colostrum, feeding the first colostrum within 6 hours from the time of birth and to farmers that fed between 4 and 6 liters of milk to preweaned calves. A ¼ point was given to farmers that used homeopathic dehorn pain relief.

[2] There were 76 herds categorized as having the best calf health and management (a score ≥ 6).

[3] There were 164 herds categorized as having other calf health and management (a score < 6).

[4] Adult cow health scores consisted of a single point for each category where a farm had ≤ 32 health events per 100 cow years, ≤ 0 cow deaths per 100 cow years, < 1.4% of cows scored as being over-conditioned (BCS > 4), < 1.7% under-conditioned (BCS ≤ 2.25), < 13.7% dirty (Udder Hygiene Score 3 & 4), < 2.5% having hock lesions (Hock Score 2 & 3), or < 2.5% lameness. There were 81 herds categorized as having the best adult cow health (score ≥ 3) and 158 herds categorized as having other adult cow health (score < 3).

Table 3. 8 Distribution of herds that received points for variables used to create the adult cow health score and graze category

		Graze Category			
		ORG[2] (n=156)	CONGR[3] (n=30)	CONNG[4] (n=55)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	Frequency (%)	P-value
Health Events	≤ 32	45 (29%)	5 (17%)	8 (15%)	0.062
Mortality	≤ 0	92 (59%)	15 (50%)	21 (38%)	0.027
Over-conditioned	< 1.4	47 (30%)	6 (20%)	4 (7%)	0.003
Under-conditioned	< 1.7	35 (22%)	6 (20%)	18 (33%)	0.259
Poor Hygiene	< 13.7	44 (28%)	6 (20%)	12 (22%)	0.483
Hock Lesions	< 2.5	51 (33%)	6 (20%)	4 (7%)	< 0.001
Lameness	< 2.5	31 (20%)	6 (20%)	14 (25%)	0.675

[1]Points were given when herds exceeded these thresholds.
[2]Orgainc herds.
[3]Conventional graze herds.
[4]Conventional non-graze herds.

Table 3. 9 Distribution of herds that received points for variables used to create the adult cow health score and state

		State			
		Wisconsin (n=117)	New York (n=92)	Oregon (n=32)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	Frequency (%)	P-value
Health Events	≤ 32	7 (6%)	41 (45%)	10 (31%)	< 0.001
Mortality	≤ 0	56 (48%)	62 (67%)	10 (31%)	< 0.001
Over-conditioned	< 1.4	22 (19%)	16 (17%)	19 (59%)	< 0.001
Under-conditioned	< 1.7	18 (15%)	25 (27%)	16 (50%)	< 0.001
Poor Hygiene	< 13.7	2 (2%)	46 (50%)	14 (44%)	< 0.001
Hock Lesions	< 2.5	26 (22%)	31 (34%)	4 (13%)	0.037
Lameness	< 2.5	28 (24%)	10 (11%)	13 (41%)	0.001

[1]Points were given when herds exceeded these thresholds.

Table 3. 10 Distribution of herds that received points for variables used to create the adult cow health score and cow housing

		Cow Housing			
		Multi-animal Pen or Freestall (n=55)	Tie Stall or Stanchion (n=61)	Pasture or Drylot (n=125)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	Frequency (%)	P-value
Health Events	≤ 32	14 (15%)	9 (15%)	35 (28%)	0.135
Mortality	≤ 0	20 (36%)	34 (56%)	74 (59%)	0.016
Over-conditioned	< 1.4	14 (25%)	7 (11%)	36 (29%)	0.031
Under-conditioned	< 1.7	25 (45%)	9 (15%)	25 (20%)	< 0.001
Poor Hygiene	< 13.7	14 (25%)	7 (11%)	41 (33%)	0.008
Hock Lesions	< 2.5	18 (33%)	6 (10%)	37 (30%)	0.005
Lameness	< 2.5	18 (33%)	7 (11%)	26 (21%)	0.020

[1]Points were given when herds exceeded these thresholds.

Table 3.11 Distribution of herds that received points for variables used to create the calf health and management score and graze categories

		Graze Category			
Variable	Thresholds[1]	ORG[2] (n=156) Frequency (%)	CONGR[3] (n=30) Frequency (%)	CONNG[4] (n=55) Frequency (%)	P-value
Calves with Diarrhea	= 0	102 (65%)	18 (60%)	39 (71%)	0.578
Calves with Respiratory	= 0	77 (49%)	19 (63%)	22 (40%)	0.119
Time of 1st Colostrum Feeding	≤ 6 hours	132 (85%)	27 (90%)	48 (87%)	0.790
Amount of Colostrum Fed	≥ 4 liters	8 (5%)	2 (7%)	3 (5%)	0.912
Disinfection of Calf Navels	Yes	90 (58%)	22 (73%)	33 (60%)	0.277
Amount of Milk Fed	4 – 6 liters	46 (29%)	7 (23%)	7 (13%)	0.019
	≥ 6 liters	46 (29%)	4 (13%)	16 (29%)	
Ability to Turn Around	Yes	131 (84%)	26 (87%)	49 (89%)	0.639
Feeding Pre-weaned Calves Starter	Yes	108 (69%)	11 (37%)	14 (25%)	< 0.001
Use of Pain Relief	Local, NSAID or sedation	36 (23%)	10 (33%)	8 (15%)	0.016
	Homeopathic	13 (8%)	0 (0%)	0 (0%)	
Method Used to Dehorn	Least Painful Methods	122 (78%)	27 (90%)	48 (87%)	0.178

[1]Points were given when herds exceeded or met these thresholds.
[2]Orgainc herds.
[3]Conventional graze herds.
[4]Conventional non-graze herds.

Table 3.11 Distribution of herds that received point for variables used to create the calf health and management score and calf housing

		Calf Housing				
		Tied in a barn (n=32)	Individual pen or hutches (n=148)	Multi-animal pen or freestall (n=47)	Pasture or drylot (n = 13)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	P-value
Calves with Diarrhea	= 0	24 (75%)	94 (64%)	33 (70%)	7 (54%)	0.427
Calves with Respiratory	= 0	14 (44%)	73 (49%)	24 (51%)	7 (54%)	0.906
Time of 1st Colostrum Feeding	≤ 6 hours or via nursing	29 (91%)	125 (84%)	40 (85%)	12 (92%)	0.844
Amount of Colostrum Fed	≥ 4 liters	3 (9%)	6 (4%)	4 (9%)	0 (0%)	0.351
Disinfection of Calf Navels	Yes	18 (56%)	91 (61%)	29 (62%)	7 (54%)	0.903
Amount of Milk Fed	4 – 6 liters	10 (31%)	40 (27%)	15 (32%)	1 (8%)	0.029
	≥ 6 liters	10 (31%)	27 (18%)	16 (34%)	6 (46%)	
Ability to Turn Around	Yes	11 (34%)	142 (96%)	40 (85%)	12 (92%)	< 0.001
Feeding Pre-weaned Calves Starter	Yes	15 (47%)	87 (59%)	28 (60%)	3 (23%)	0.060
Use of Pain Relief	Yes	6 (19%)	36 (24%)	9 (19%)	2 (15%)	0.522
Method Used to Dehorn	Least painful methods	25 (78%)	126 (85%)	37 (79%)	8 (62%)	0.155

[1]Points were given when herds exceeded or met these thresholds.

CONCLUSION

Ensuring animal wellbeing is essential for the future of the United States dairy industry. As consumers become more distant from animal agriculture their understanding of how animals are treated and maintaining trust in the industry has become a priority. Welfare audits and assessments have been designed with this priority in mind. Many management practices and biological measures can be used to indicate appropriate use of management and animal wellbeing on dairy farms. The objectives of this thesis were to determine indicators and identify management practices that reflect positive wellbeing, while comparing to current welfare audit and assessment programs in the United States and how the indices and practices compare on ORG and CON dairies.

Requirements for animal based measures and management practices from three common welfare programs were evaluated on 292 ORG and CON dairies. Few of the small farms in this dataset would have met the requirements of the welfare programs for animal based measures such as body condition, lameness, hygiene and hock lesions. Veterinarian usage was minimal, although CONNG herds had the greatest proportion of farmers that reported regular use of a veterinarian. Very few farms were found to maintain written protocols for clinical mastitis and milking routines. Management areas of concern found across this study population include amount of colostrum provided to calves, disinfection of calf navels, feeding preweaned calves starter, age at dehorning and the use of pain relief.

Two objective scores for adult cow health, calf health and calf management were created to develop measureable indicators for the assessment of welfare on an individual farm basis. The scores were used to distinguish farms with the best welfare. Conventional

non-graze herds were less likely to be categorized as having the best calf health and management as compared to ORG herds. Whereas CONGR herds were less likely to be categorized as having the best adult cow health events score compared to ORG farms. State was significantly associated with adult cow health scores. Farms in WI were less likely to be categorized as having the best adult cow health compared to OR and NY farms. Farms that primarily housed calves in individual pens, hutches, freestalls and multi-animals pens were more likely to be categorized as having the best calf health and management.

This study is unique as it compares ORG and CON dairy farms to indicators of dairy cattle wellbeing. Many management practices and animal based measures were found to be feasible for measuring animal welfare. Two practical scores were created with thresholds for the assessment of calf and adult cow wellbeing. The thresholds created provide farmers with an opportunity to compare their herd's wellbeing amongst a variety of other herds.

APPENDICES FOR WISCONSIN HERDS

1.1 Appendix Herd-level descriptive statistics of variables that created the adult cow health score (n = 117)[1]

Variables	Thresholds	Mean	SD	Min	10th	25th	Median	75th	90th	Max
Health events[2]	≤ 56.59	102.4	0.73	0.00	34.56	56.59	82.21	131.81	197.30	498.63
Mortality[3]	≤ 0.00	5.0	0.07	0.00	0.00	0.00	3.04	7.66	12.67	35.37
Over Conditioned[4]	< 2.08	9.14%	9.77	0.00%	0.00%	2.08%	6.06%	12.24%	20.00%	50.00%
Under Conditioned[5]	< 3.39	11.94%	13.33	0.00%	0.00%	3.39%	7.81%	16.42%	25.00%	88.64%
Lameness[6]	< 2.50	8.33%	8.72	0.00%	0.00%	2.50%	7.04%	10.34%	18.18%	53.57%
Dirty Udder Hygiene[7]	< 36.67	48.76%	17.97	7.41%	25.00%	36.67%	50.00%	60.00%	70.31%	93.44%
Hock Lesions[8]	< 3.17	20.52%	22.42	0.00%	0.00%	3.17%	12.50%	29.17%	60.00%	95.45%

[1]Percentiles of health events, mortality, body condition variables, udder hygiene variables, lameness and hock lesions to show the cutoffs used to create the adult cow health score.

[2] Total health events per 100 cow years. The threshold for least sick cows of ≤ 56.59 was based on the 25th percentile. Health events included: mastitis, milk fever, metritis, lameness, displace abomasum, ketosis, respiratory and foot infections.

[3] Total dead cows per 100 cow years. The threshold for least cow deaths of ≤ 0.0 was based on the 50th percentile.

[4] Based on body condition > 4.0, the threshold for least over-conditioned cows of < 2.08% was based on the 25th percentile.

[5] Based on body condition ≤ 2.25 the threshold for least under-conditioned cows of < 3.39% was based on the 25th percentile.

[6] Based on lameness scores 3 & 4 the threshold for least lame cows of < 2.50% was based on the 25th percentile.

[7] Based on udder hygiene score 3 & 4 the threshold for least dirty cows of < 36.67% was based on the 25th percentile.

[8] Based on hock scores 2 & 3 the threshold for least cows with hock lesions of < 3.17% was based on the 25th percentile.

1.2 Appendix Herd-level descriptive statistics of pre-weaned calves scored as having diarrhea or respiratory disease (n = 117)[1]

Variables	Unit of Measurement	Threshold	Mean	St. Deviation	Min	10th	25th	Median	75th	90th	Max
Respiratory Disease[2]	% of calves	≤ 0.00%	8.19%	0.14	0.00%	0.00%	0.00%	0.00%	11.76%	25.00%	75.00%
Diarrhea[3]	% of calves	≤ 0.00%	1.87%	0.05	0.00%	0.00%	0.00%	0.00%	0.00%	9.09%	33.33%

[1]Percentiles of calves with respiratory disease and diarrhea to show the cutoffs used to create the calf health score.

[2] Based on the respiratory score (calves scored with either, nasal discharge, ocular discharge, droopy ears or cough) the threshold for least calves scored as having respiratory disease of ≤ 0% was based on the 50th percentile.

[3] Based on calves scored as having diarrhea the threshold for least calves scored of ≤ 0% was based on the 75th percentile.

1.3 Appendix Descriptive statistics of variables that created the calf health and management score

Variables	Outcome	Frequency (%)
At least one calf unable to turn around	Unable to Turn Around	1 (1%)
	Able to Turn Around	116 (99%)
Dipping of neonatal navels	No Dipping of Navels	58 (50%)
	Dipping of Navels	59 (50%)
Feeding preweaned calves starter	No Starter Fed	43 (37%)
	Starter Fed	74 (63%)
Use of any pain relief while dehorning	No Pain Relief Used	96 (82%)
	Local, NSAID or sedation	13 (11%)
	Homeopathic	8 (7%)
Amount of milk fed	< 4 liters	62 (53%)
	≥ 4 and < 6 liters	35 (30%)
	≥ 6 liters	20 (17%)
Painful Method Used to Dehorn	Scoop, Gouge or Cut Out	26 (22%)
	Other Less Painful Methods	91 (78%)
Time of First Colostrum	>6 hours or Received Via the Dam	18 (15%)
	≤ 6 hours After Birth	99 (85%)
Amount of Colostrum	< 4 Liters	113 (97%)
	≥ 4 Liters	4 (3%)
Calves with Diarrhea	> 0 calves with symptom	18 (15%)
	= 0 calves with symptom	99 (85%)
Calves with Respiratory	> 0 calves with symptom	49 (42%)
	= 0 calves with symptom	68 (58%)

1.4 Appendix Associations between graze category, herd size, season of visit, primary breed cow housing and routine vet visits with adult cow health scores

		Cow Health[1]					
Categories		Best Herds (%)[2]	Other Herds (%)[3]	Estimate (SE)	Odds Ratio[4]	95% CI	P-value
Intercept				-0.68			
Graze Category[5]		40	77				0.052
	ORG	31 (41.9%)	43 (58.1%)	Reference			
	CON	9 (20.9%)	34 (79.1%)	-0.65	0.28	(0.08 , 1.01)[11]	
Herd Size[6]		40	77				0.484
	Small	35 (35.7%)	63 (64.3%)	Reference			
	Large	5 (26.3%)	14 (73.7%)	-0.31			
Season[7]		40	77				0.041
	Winter	4 (13.3%)	26 (86.7%)	Reference			
	Autumn	7 (26.9%)	19 (73.1%)	-0.45			
	Spring	9 (52.9%)	8 (47.1%)	1.08	16.73	(1.89 , 147.77)[12]	
	Summer	20 (45.4%)	24 (54.5%)	1.11	17.18	(2.22 , 133.25)[13]	
Breed[8]		40	77				0.001
	Other	22 (66.7%)	11 (33.3%)	Reference			
	Holstein	18 (21.4%)	66 (78.6%)	-0.95	0.15	(0.05 , 0.47)[14]	
Cow Housing[9]		40	77				0.030
	Multi-animal Pen or Freestall	11 (42.3%)	15 (57.7%)	Reference			
	Tie Stall or Stanchion	4 (11.1%)	32 (88.9%)	-0.39			
	Pasture or Drylot	25 (45.4%)	30 (54.5%)	-0.90	0.11	(0.02 , 0.64)[15]	
Routine Vet Visits[10]		40	77				0.195
	Some	6 (18.8%)	26 (81.2%)	Reference			
	None	28 (41.8%)	39 (58.2%)	0.11			
	Many	6 (33.3%)	12 (66.7%)	0.74			

[1] Adult cow health scores consisted of a single point for each category where a farm had ≤ 56.59 health events per 100 cow years, ≤ 0 cow deaths per 100 cow years, < 2.08% of cows scored as being over-conditioned (BCS > 4), < 3.39% under-conditioned (BCS ≤ 2.25), < 36.67% dirty (Udder Hygiene Score 3 & 4), < 3.17% having hock lesions (Hock Score 2 & 3), or < 2.50% lameness.

[2] There were 40 herds categorized as having the best adult cow health (score ≥ 3).
[3] There were 77 herds categorized as having other adult cow health (score < 3).
[4] Odds Ratios are only reported for significant variables.
[5] Graze Category was defined as ORG (n = 74), CON (n = 43).
[6] Herd Size was defined as Small (< 100 Cows, n = 98), Large (> 100 Cows, n = 19).
[7] Season was defined as Winter (n = 67), Autumn (n = 45), Spring (n = 65), Summer (n = 85).
[8] Breed was defined as Holstein (n = 84) or Other (including Jersey; n = 33).
[9]Cow Housing was defined as Pasture or Drylot (n = 125), Multi-animal Pen or Freestall (n = 55), Tie Stall or Stanchion (n = 61),
[10] Routine Vet Visits was defined as None (n = 136), Some (7.5 – 20 visits, n = 93) and Many (> 20 visits, n = 33).
[11] There was a trend for CON farms to be less likely categorized as having the best adult cow health scores as compared to ORG herds.
[12] Herds that were visited during the Spring were 16.7 times likely to be categorized as having the best adult cow health score as compared to herds that were visited during the Winter.
[13] Herds that were visited during the Summer were 7.2 times more likely to be categorized as having the best adult cow health score as compared to herds that were visited during the Winter.
[14] Herds that were primarily Holstein were less likely to be categorized as having the best adult cow health score as compared to herds that were primarily Other breeds (including Jersey).
[15] Farmers that primarily housed their cattle on Pasture or Drylots were less likely to be categorized as having the best adult cow health score as compared farmers that primarily housed their cattle in Multi-animal Pens or Freestalls.

1.5 Appendix Associations between graze category, and herd size with calf health and management scores

	Calf Health & Management Score[1]					
Categories	Best Health & Management (%)[2]	Other (%)[3]	Estimate (SE)	Odds Ratio[4]	95% CI	P-value
Intercept			-1.00			
Graze Category[5]	39	78				0.014
ORG	31 (41.9%)	43 (58.1%)	Reference			
CON	8 (18.6%)	35 (81.4%)	-0.57	0.32	(0.13 , 0.79)[7]	
Herd Size[6]	39	78				0.629
Small	34 (34.7%)	64 (65.3%)	Reference			
Large	5 (26.3%)	14 (73.7%)	-0.14			

[1]Calf health and management score consisted of one point for each management area that may positively impacts the wellbeing of calves including: housing calves in an area in which they are able to turn around, dipping neonate navels, feeding ≥ 6 liters of milk to preweaned calves, feeding grain to preweaned calves, using pain relief (local, NSAID, sedation) during dehorning, and using less painful method to dehorn calves, farms that had > 0 calves scored with respiratory disease and farms that had > 0 calves scored as having diarrhea. Additionally a ½ point was given to farmers that reported nursing for colostrum as the sole source for colostrum, feeding ≥ 4 liters of colostrum, feeding the first colostrum within 6 hours from the time of birth and to farmers that fed between 4 and 6 liters of milk to preweaned calves. A ¼ was given to farmers that used homeopathic pain relief while dehorning.

[2] There were 39 herds categorized as having the best calf health and management (a score ≥ 6).

[3] There were 78 herds categorized as having other calf health and management (a score < 6).

[4] Odds Ratios are only reported for significant variables.

[5] Graze Category was defined as ORG (n = 74), CON (n = 43).

[6] Herd Size was defined as Small (< 100 Cows, n = 98), Large (> 100 Cows, n = 19).

[7] Conventional farmers were less likely to be categorized as having the best calf health and management as compared to ORG farmers.

1.6 Appendix Associations among calf health and management score and adult cow health events score

	Management Score[1]		
Categories	Best Herds (%)[2]	Other Herds (%)[3]	P-value
Intercept			
Adult Cow Health Score[4]	39	78	0.582
Best Herds	12 (30%)	28 (70%)	
Other Herds	27 (35%)	50 (65%)	

[1] Calf management score consisted of one point for each management area that may positively impact the wellbeing of calves including: housing calves in an area in which they are able to turn around, dipping neonate navels, feeding ≥ 6 liters of milk to preweaned calves, feeding grain to preweaned calves, using pain relief (local, NSAID, sedation) during dehorning, and using less painful method to dehorn calves, farms that had > 0 calves scored with respiratory disease and farms that had > 0 calves scored as having diarrhea. Additionally a ½ point was given to farmers that reported nursing for colostrum as the sole source for colostrum, feeding ≥ 4 liters of colostrum, feeding the first colostrum within 6 hours from the time of birth and to farmers that fed between 4 and 6 liters of milk to preweaned calves. A ¼ point was given to farmers that used homeopathic dehorn pain relief.

[2] There were 39 herds categorized as having the best calf health and management (a score ≥ 6).

[3] There were 78 herds categorized as having other calf health and management (a score < 6).

[4] Adult cow health scores consisted of a single point for each category where a farm had ≤ 56.59 health events per 100 cow years, ≤ 0 cow deaths per 100 cow years, < 2.08% of cows scored as being over-conditioned (BCS > 4), < 3.39% under-conditioned (BCS ≤ 2.25), < 36.67% dirty (Udder Hygiene Score 3 & 4), < 3.17% having hock lesions (Hock Score 2 & 3), or < 2.50% lameness. There were 40 herds categorized as having the best adult cow health (score ≥ 3) and 77 herds categorized as having other adult cow health (score < 3).

1.7 Appendix Distribution of herds that received points for variables used to create the adult cow health score by season of visit

		Season				
Variable	Thresholds[1]	Winter (n=30) Frequency (%)	Autumn (n=26) Frequency (%)	Spring (n=17) Frequency (%)	Summer (n=44) Frequency (%)	P-value
Health Events	≤ 56.59	5 (17%)	4 (15%)	4 (24%)	16 (36%)	0.162
Mortality	≤ 0.00	13 (43%)	8 (31%)	9 (53%)	26 (59%)	0.128
Over-conditioned	< 2.08	9 (30.0%)	7 (27%)	3 (18%)	10 (23%)	0.793
Under-conditioned	< 3.39	6 (20%)	7 (27%)	6 (35%)	11 (25%)	0.714
Lameness	< 2.50	5 (17%)	5 (19%)	8 (47%)	10 (23%)	0.102
Poor Hygiene	< 36.67	9 (30%)	3 (12%)	9 (53%)	10 (23%)	0.026
Hock Lesions	< 3.17	5 (17%)	8 (31%)	1 (6%)	15 (34%)	0.070

[1]Points were given when herds exceeded these thresholds.

1.8 Appendix Distribution of herds that received points for variables used to create the adult cow health score by primary breed

		Breed		
		Holstein (n=84)	Other (n=33)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	P-value
Health Events	≤ 56.59	18 (21%)	11 (33%)	0.180
Mortality	≤ 0.00	32 (38%)	24 (73%)	< 0.001
Over-conditioned	< 2.08	20 (24%)	9 (27%)	0.696
Under-conditioned	< 3.39	21 (25%)	9 (27%)	0.800
Lameness	< 2.50	14 (17%)	14 (42%)	0.003
Poor Hygiene	< 36.67	16 (19%)	15 (45%)	0.004
Hock Lesions	< 3.17	19 (23%)	10 (30%)	0.386

[1]Points were given when herds exceeded these thresholds.

1.9 Appendix Distribution of herds that received points for variables used to create the adult cow health score by cow housing

		Cow Housing			
		Multi-animal Pen or Freestall (n=26)	Tie Stall or Stanchion (n=36)	Pasture or Drylot (n=55)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	Frequency (%)	P-value
Health Events	≤ 56.59	9 (35%)	3 (8%)	17 (31%)	0.015
Mortality	≤ 0.00	12 (46%)	12 (33%)	32 (58%)	0.066
Over-conditioned	< 2.08	7 (27%)	6 (17%)	16 (29%)	0.390
Under-conditioned	< 3.39	11 (42%)	8 (22%)	11 (20%)	0.085
Lameness	< 2.50	6 (23%)	5 (14%)	17 (31%)	0.176
Poor Hygiene	< 36.67	5 (19%)	10 (28%)	16 (29%)	0.630
Hock Lesions	< 3.17	9 (35%)	3 (8%)	17 (31%)	0.015

[1]Points were given when herds exceeded these thresholds.

1.10 Appendix Distribution of herds that received point for variables used to create the calf health and management score and calf housing by graze category

		Graze Category		
		ORG (n=74)	CON (n=43)	
Variable	Thresholds[1]	Frequency (%)	Frequency (%)	P-value
Calves with Diarrhea	= 0	62 (84%)	37 (86%)	0.744
Calves with Respiratory	= 0	43 (58%)	25 (58%)	0.997
Time of 1st Colostrum Feeding	≤ 6 hours or via nursing	61 (82%)	38 (88%)	0.391
Amount of Colostrum Fed	≥ 4 liters	3 (4%)	1 (2%)	0.620
Disinfection of Calf Navels	Yes	36 (49%)	23 (53%)	0.614
Amount of Milk Fed	4 – 6 liters	14 (19%)	6 (14%)	0.016
	≥ 6 liters	28 (38%)	7 (16%)	
Ability to Turn Around	Yes	74 (100%)	42 (98%)	0.368
Feeding Pre-weaned Calves Starter	Yes	64 (86%)	10 (23%)	< 0.001
Use of Pain Relief	Local, NSAID or sedation	9 (12%)	4 (9%)	0.055
	Homeopathic	8 (11%)	0 (0%)	
Method Used to Dehorn	Least painful methods	56 (76%)	35 (81%)	0.4731

[1]Points were given when herds exceeded or met these thresholds.