Introducing Heifers to Freestalls Using a Social Model

by

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Abstract

Older conspecifics can model important behaviours in group-living species, potentially reducing reliance on trial and error learning. On many farms animals are segregated by age, preventing this social modelling from occurring. The modern dairy farm is an ideal model for studying how young cattle adapt to new environments, and how these adaptations may improve through the use of social models. Freestalls, a common housing system for dairy cattle, contain individual cubicles designed to provide a clean and easy to maintain lying surfaces for cattle. However, learning to use these stalls can be a challenge for naïve animals. When introduced to freestalls for the first time, some animals refuse to lie in these stalls, choosing instead to lie in the wet manure alleys. The aim of this study was to compare the behavioural responses of naïve dairy heifers when introduced to freestalls with and without a social model that was familiar with freestall housing. Naïve Holstein heifers were randomly assigned into pairs; half were assigned a social model, and the remaining pairs were left as control groups, using 11 groups per treatment. When first introduced to freestall housing, all heifers showed a mean (± SE) 2.5-3 ± 0.6 h/d decrease in lying time and around a 1 ± 0.4 h/d decrease in average feeding time, while average time spent standing in the alley increased by 2 ± 0.4 h/d with these behaviours returning to baseline within two days. Heifers moved without a social model were more likely to lie in the alley versus heifers moved with an experienced social companion, but otherwise lying behaviour was not affected by treatment. These results indicate that the transition to freestall housing is difficult for all heifers, and providing naïve heifers with an experienced social model can reduce occurrences of undesirable stall refusal behaviour.

Lay Summary

Young dairy cows can have difficulty adapting to the lying stalls commonly used on dairy farms, resulting in animals lying in manure outside of the stalls. By providing animals with 'social models' (i.e. older cattle already familiar with stalls) we hoped to improve this transition. In this study we introduced young cattle to stalls for the first time with and without experienced social models. Animals with social models were less likely to lie in the alleys, suggesting that this method could be used to reduce undesirable alley lying behaviour.

Preface

I completed this thesis under the supervision of Dr. Marina A.G. von Keyserlingk. In addition to Dr. von Keyserlingk my supervisory committee included Drs. Daniel M. Weary and Richard R. Barichello, all from The University of British Columbia (UBC). The study described in my thesis was approved by UBC's Animal Care Committee (#A14-0245), and the animals were cared for according to the guidelines outlined by the Canadian Council of Animal Care (2009).

Chapter 2 was co-authored with M.A.G. von Keyserlingk and D.M. Weary (University of British Columbia). Co-authors supervised the project design, analysed data and edited drafts. The main ideas were developed by M.A.G. von Keyserlingk and D.M. Weary, while I was responsible for designing and executing the study, data collection and the daily running of the study.

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cm - centimeters

d - day

DM – dry matter

h – hour(s)

IMI – intramammary infection

kg – kilogram

m - meters

min – minute(s)

mo – month(s)

SCC – somatic cell count

SD – standard deviation

SE – standard error

UBC – University of British Columbia

W – watts

wks - weeks

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To the girls.

Chapter 1: Introduction

The past 50 years has seen dramatic changes in the North American dairy industry. Farm size has increased, such that now more than 60% of the milk supply in the United States is produced on farms with over 500 cows (USDA-NASS, 2012). Average herd size has also increased, with a trend towards cows being managed in fewer, yet larger herds (USDA-NASS, 2012). These changes have been accompanied with a move toward zero-grazing systems where cows are housed indoors year-round, a trend that has been increasingly questioned regarding its implications on animal welfare (Schuppli et al., 2014). One common indoor housing system for dairy cattle is freestalls. In the United States, nearly 52% of lactating cows on farms of over 500 animals are housed in freestalls (USDA, 2016).

One problem with more intensive housing systems like freestall barns is that it may be difficult for animals to transition to more restrictive housing. Previous work has shown that some animals have difficulty adapting to freestalls when first introduced. For instance, rates of stall refusal, where animals lie outside of their stalls, have been reported to range from 0-55% (averaged 6%; Kjæstad & Myren, 2001). Dairy heifers have also been reported to lie in the manure alley upon introduction to freestall housing (von Keyserlingk et al., 2011), potentially leading to reduced animal cleanliness. Lying in the manure alley also puts adult cows at risk of intramammary infection (Breen et al., 2009).

Few studies have investigated methods of improving heifer adaptation to freestalls. O'Connell et al. (1993) found that heifers trained to use freestalls as weanlings were more likely to lie in freestalls as adults. However, to the best of my knowledge, no studies have examined the social factors affecting heifer lying behaviour in freestalls.

In this review I will survey various health, management and social factors that affect lying behaviour in dairy cattle, followed by recommendations for improving lying behaviour and reducing social stressors in freestalls. Since my thesis is focused on dairy heifers, I will proceed with an emphasis on factors that may affect the lying behaviour in heifers upon introduction to freestalls, and attempt to identify practical solutions to improve the health and welfare of dairy heifers housed on commercial freestall farms.

1.1 FACTORS THAT AFFECT FREESTALL USE

Dairy cattle lying behaviour, most importantly the frequency and duration of lying bouts and total time spent lying down, has been used as a measure of 'cow comfort' for nearly two decades (Haley et al., 2000). Dairy cattle are highly motivated to lie down (Jensen et al., 2005), and will work (Jensen et al., 2004) and forgo food and social contact to increase daily lying times (Munksgaard et al., 2005). However, certain housing systems may be configured in ways that negatively affect lying behaviour. Some have argued that interferences in highly motivated and important behaviours such as lying may cause frustration in cattle (Dawkins, 1988; Broom, 1991).

The freestall housing system for dairy cattle contains separate areas for feeding and lying, including stall partitions that encourage cows to lie down in rows. Invented in 1962 by Major Bramley (Bramley, 1962), this type of lying area helps to prevent cows from defaecating in the stall, in part because the dividers between stalls and the neck rail prevent cows from entering the stall completely (Figure 1).

Figure 1 – Freestall barn showing lying stalls and sand bedding. Horizontal neck rails (A) at the top of lying stalls ensure that lying cows must back up to fully stand and defaecate/urinate, while stall dividers (B) limit lateral movement. Photo credit: Anne-Marieke Smid, 2017

The cow enters the stall and is required to lower her head under the neck rail before engaging the sequence of behaviours that result in her lying down. Once the lying bout is completed she stands up, but given the placement of the neck rail and the brisket board, (a barrier located in the bedding to prevent cows from lying too far forward in stalls), is forced to step back. As cows commonly defaecate after standing up, this sequence reduces the chance of faeces and urine contaminating the stall surface. The freestall was thought to reduce costs associated with bedding and labour required for stall maintenance, as well as reduces the risk of mastitis in lactating cows compared to open pack systems (Bramley, 1962; Schmisseur et al., 1966; Jackson & Bramley, 1983). Cows housed in freestalls were also thought to be less dirty than cows housed in open packs (Albright and Alliston, 1971; Bakken, 1981; Berry, 1998). In summary, the design of the freestall aims to provide a clean, comfortable lying surface for cows while controlling lateral and lengthwise movement through the use of stall dividers, neck rails and brisket boards (Ruud and Bøe, 2011).

1.1.1 HEALTH

1.1.1.1 Lameness

Lameness, defined as any abnormality which causes a cow to change the way they walk, is an important welfare issue facing dairy cattle today (Cook and Nordlund, 2009) and is responsible for significant production losses in cattle (Huxley, 2013). Lameness is considered to be painful (Rushen et al., 2008; Flower and Weary, 2009) and is associated with reduced milk production and high culling rates in cattle (Huxley, 2013). Approximately 20% of all intensively managed dairy cows are lame at any given time (Wells et al., 1993; Clarkson et al., 1996; Whay et al., 2002; Cook, 2003) and the prevalence of clinical lameness in freestalls was found to be 30% in British Columbia, Canada and 55% in the Northeastern United States (von Keyserlingk et al., 2012). 'Lameness' is not a single condition but a common symptom of many different diseases. Although the pathogenesis and aetiology of these diseases are still poorly understood (Huxley, 2012), claw horn lesions, including sole hemorrhage, sole ulcers and white line disease are common causes of dairy cattle lameness (Greenough, 1997; Cook & Nordlund, 2009).

Four major factors for the development of claw lesions contributing to lameness have been identified. Firstly, nutrition can be a factor, including nutritional imbalances in trace elements and vitamins such as biotin (Tomlinson et al., 2004) and management of sub-acute ruminal acidosis (Cook et al., 2004; Thoefner et al., 2004). Secondly, hormonal changes during calving may be associated with changes in the connective tissue around the claw, impairing resilience to external stresses (Webster, 2001; Tarlton et al., 2002). Thirdly, external trauma can result in traumatic injuries of the claw (Chesterton et al., 1989) or thinning of the sole from excessive wear (Shearer et al., 2006). Lastly, certain pathogens such as *Fusobacterium necrophorum* and various species of the genus Treponema can lead to infectious lesions of the claw (Greenough, 1997).

The influence of the environment can also have a profound effect on claw health and lameness prevalence in dairy herds (reviewed by Cook and Nordlund, 2009). For example, Haskell et al. (2006) reported lameness prevalence of 39% in herds housed in freestalls year-round, compared with 17% in freestall herds that allowed cattle access to pasture during the year. Although some pasture-based systems have significant lameness problems (Chesterton et al., 1989; Tranter & Morris, 1991; Sepúlveda-Varas et al., 2014) others have reported lower prevalence versus freestall housing (Haskell et al., 2006; Olmos et al., 2009; Fabian et al., 2014). Lower levels of lameness have also been identified in open packs (Webster, 2001; Somers et al., 2003) and compost barns (Barberg et al., 2007), perhaps due to a larger proportion of time that animals spend lying on a comfortable surface, and a softer flooring surface that cushions the claw horn when cows rise to stand (Singh et al., 1993a). Reductions in daily lying times have been associated with lameness (Leonard et al., 1996; Cook et al., 2004), although increased lying time has also been recorded in lame cows who performed fewer but longer lying bouts (Sepúlveda-Varas et al., 2014).

Several studies have found lower rates of lameness in tie-stall herds compared with freestall herds (Wells et al., 1993; Bergsten and Herlin, 1996; Cook, 2003; Sogstad et al., 2005), although concerns have been raised about restrictions of movement and expression of natural behaviours of animals in tie stalls (Boogaard et al., 2011; Popescu et al., 2013). While great variation in lameness prevalence exists within each management system (see von Keyserlingk et al., 2012), zero-grazed freestall systems appear to have the highest rates of lameness, suggesting that freestalls expose cattle to adverse environmental conditions such as increased exposure of the claw to concrete flooring (Cook & Nordlund, 2009). The use of texturized rubber on feed bunk alleys and walkways, in concert with deep sand bedding in stalls, consistently rank as conferring the greatest improvements to claw health according to several indices (Vokey et al., 2001).

1.1.1.2 Hock lesions

Damage to the hock region is the most common skin injury in dairy cows (Veissier et al., 2004) and the term ‘hock lesion’ describes conditions ranging from minor hair loss to ulceration and swelling (Laven and Liversey, 2011). Hock lesions tend to be most prevalent in inadequately bedded freestall barns that use stall bases made of concrete, rubber mats or mattresses compared with deep-bedded freestalls and open packs (Fulwider et al., 2007). Hock lesions and lameness are closely linked (Brenninkmeyer et al., 2012; Burrow et al., 2012; Lim et al., 2013), and since most injuries to the hock are due to housing system (Rutheford et al., 2008), the prevalence of hock injuries may be a good indicator of welfare. Indeed, hock lesion rates of 100% are not uncommon in freestall barns that do not provide adequate bedding and space (Kielland et al., 2009; Brenninkmeyer et al., 2012).

1.1.1.3 Mastitis

Mastitis, a condition defined as inflammation of the mammary gland, is the most common and arguably the most economically costly disease facing the dairy industry today (Østerås et al., 2005). Milk somatic cell count (SCC) is often used to measure mammary inflammation as an increase in SCC is strongly correlated with intramammary infection (IMI) (Eberhart et al., 1979; Dohoo and Leslie, 1991).

Although less prevalent than in older cows, mastitis is not uncommon in heifers, with mammary quarter infection prevalence rates ranging from 29-75% prepartum and 12-46% at parturition (Fox, 2009). Coagulase-negative and positive Staphylococci species, environmental Streptococci species and various coliforms are the most prevalent pathogens associated with mastitis (Hogan, 1997). In contrast to the increased lying times normally associated with sick animals (Broom, 2006; Dantzer & Kelly, 2007), mastitic cows may display reduced lying times (Fogsgaard et al., 2015), likely due to the pain associated with lying down and exerting pressure on infected udders (Siivonen et al., 2011; Fogsgaard et al., 2012). If a cow with mastitis is unable to lie down for long periods (Fitzpatrick et al., 1998; Leslie et al., 2010), she may become increasingly frustrated and restless over time (Fogsgaard et al., 2015).

1.1.2 MANAGEMENT FACTORS

1.1.2.1 Bedding quality & quantity

Cows prefer to lie on dry bedding and spend less time lying in stalls and more time standing in the alleys when only wet sawdust bedding is provided (Fregonesi et al., 2007a). Indeed, in the latter study 2 cows chose to lie down on the rubber flooring outside of the stall rather than in wet bedding in the freestall. Sawdust has a higher water holding capacity than sand (Ward et al., 2000), and the dry matter content decreases rapidly with use by the animals, leading to increased bacterial levels on the bedding and teats (Zdanowicz et al., 2004). Organic bedding such as sawdust has been consistently documented to have higher bacterial counts than sand (Fairchild et al., 1982; Hogan et al., 1989) which leads to higher bacterial counts on teat ends

(Natzke and Le Clair, 1975; Rendos et al., 1975; Bishop, et al., 1981). Additionally, deep sand bedding is associated with reduced prevalence of claw lesions indicative of lameness (Vokey et al., 2001), and lower levels of hock lesions (Fulwider et al., 2007). Therefore, many authors consider sand to be the ideal material for freestall bedding (Bickert, 1999; Allen, 2007) as it provides a cool and comfortable lying surface, limits bacterial growth, has low initial levels of moisture, and reduces slippage in alleyways and stalls (Stowell and Inglis, 2000; Allen, 2007; Buli et al., 2010).

Increased lying times have been reported when cows are provided more bedding (Tucker et al., 2003; Tucker and Weary, 2004; Tucker et al., 2009). It has been suggested that deep-bedded sand stalls provide increased compression of sand resulting in a more comfortable and softer lying surfaces (Fulwinder and Palmer, 2004). Stall maintenance has been shown to have a profound effect on lying time; Drissler et al. (2005) found that for every 1-cm decrease in sand bedding depth, cattle decreased lying time by 11 min/24 h. Similarly, Tucker et al. (2009) reported lying time increases of 3 min and 12 min/24 h per additional kilogram of shavings and straw, respectively. These findings highlight the importance of providing adequate quantities of good quality bedding to ensure dairy cattle are able to perform normal lying behaviours.

1.1.2.2 Stall design

In addition to appropriate bedding, the dimensions and design of individual stalls can affect behaviour. For example, cows spend more time lying down in wide stalls (132 cm) versus narrow stalls (112 cm) (Tucker et al., 2004), and in stalls that have no brisket board (Tucker et al., 2006). Placement of the neck rail can affect dairy cattle standing behaviour. More restrictive placement (closer to the curb) results in higher levels of perching behaviour (cows stand with only their two front legs in the stall), a behaviour known to increase the risk of lameness (Galindo & Broom, 2000; Flower & Weary, 2002). Conversely, overly permissive placement (further from the curb) results in dirtier stalls and reduced udder hygiene (Tucker et al., 2005; Fregonesi et al., 2009). Cows housed in freestalls with restrictively placed neck rails are at increased risk of developing lameness (Bernardi et al., 2009), which may be due to restricted access to dry comfortable areas (i.e., stalls) in which to stand and lie down.

1.1.2.3 Animal and stall hygiene

Cow cleanliness is important for maintaining hygienic milk production and improving the welfare of animals by promoting good udder health (Schreiner & Ruegg, 2003; Munoz et al., 2008; Breen et al., 2008). Reduced udder hygiene can lead to increased rates of mastitis (Schreiner & Ruegg, 2003; Reneau et al., 2005), and studies have reported that the risk of IMI is associated with the number of mastitis pathogens present on the teat end (Neave et al., 1966; Pankey, 1989). Bacterial counts in bedding have been correlated with bacterial counts on teat ends (Hogan et al., 1999; Zdanowicz et al., 2004), and to rates of clinical mastitis (Hogan et al., 1989). Cleanliness of the udder affects the number and variety of bacteria present on the teat surface, and dirty teats may be a source of environmental bacteria in milk (Galton et al., 1982; Magnusson et al., 2007).

Risk factors for cows becoming soiled include increased air humidity, high stall stocking densities, the absence of bedding material, and liquid versus more consistent manure (Ruud et al., 2010; Hauge et al., 2012). Low-positioned neck rails (Ruud et al., 2010) and failure of farmers to clean animals (Hauge et al., 2012) are also associated with reduced animal hygiene. Additionally, the use of an automatic floor scraper has been shown to reduce manure contamination of the area in the freestall where the udder normally contacts the bedding material, improving the cleanliness of stalls, udders and teats (Magnusson et al., 2008). Cows display reduced lying times when only wet bedding is provided (Fregonesi et al., 2007a) and may reduce lying times on soiled bedding. Additionally, mastitic cows may display reduced lying times (Fogsgaard et al., 2015), likely due to the pain associated with lying down and exerting pressure on infected udders (Siivonen et al., 2011; Fogsgaard et al., 2012; Medrano-Galarza et al., 2012).

1.1.2.4 Stocking density & regrouping

Stocking density at the lying stalls refers to the number of animals in a pen relative to the number of available lying stalls; a stall stocking density of 100% translates to one animal per available stall. Overstocking, or housing animals at stocking densities above 100%, is a common management practice (Bewley et al., 2001). It is estimated that 4 out of every 10 freestall barns in the United States contain more cows than available stalls (USDA, 2010). This results in some animals not having a stall available to lie in, resulting in reductions to daily lying times and increased displacements from stalls (Fregonesi et al., 2007b). Furthermore, providing insufficient stalls prevents a group of cattle from synchronizing their lying behaviour (Hasegawa et al., 1997).

Cows are regularly regrouped to maintain homogenous groups in milk yield and stage of lactation (Grant and Albright, 2001), with many cows regrouped 4 to 5 times in a lactation cycle (von Keyserlingk et al., 2008). This is a contrast to feral cattle herds where cows, heifers, and calves live in well-established herds that rarely accept new members into groups (see review by Bouissou et al., 2001). Regrouping is disruptive to dairy cattle, causing increased displacements at the feed bunk, and decreases in lying times, number of lying bouts, allogrooming and milk production in the hours and days following regrouping (von Keyserlingk et al., 2008). Moreover, repeated regroupings appears to increase the occurrences of agonistic interactions in heifers (Raussi et al., 2005). However, some work suggests that reduced stocking densities in lying stalls can mitigate the negative effects of regrouping on lying behaviour and frequency of displacements at the feed bunk (Talebi et al., 2014).

1.2 SOCIAL FACTORS THAT AFFECT FREESTALL USE IN DAIRY HEIFERS

Domesticated cattle are gregarious animals whose ancestors lived in stable groups of related females and their offspring (Hall 1983; Reinhardt et al., 1986). Gregarious herbivores learn much about their environment by observing and interacting with experienced conspecifics. Social learning, the process through which animals learn from others rather than from direct experience, plays a crucial role in group-living animals (Gariépy et al., 2014).

Experienced individuals often affect the foraging decisions and site selection patterns of younger herd members (Galef and Giraldeau, 2001; Launchbaugh and Howrey, 2005). Individuals from many species rely on obtaining information from experienced conspecifics about the proximity and identity of predators, the distribution and palatability of potential food resources, and their status in various social relationships within the herd (Nicol, 1995). Social influences may increase a young individual's fitness by influencing their strategies to avoid predators (Galef and Laland, 2005) and obtaining food in environments with temporal variations in food availability (Boyd and Richerson, 1983).

Given the ubiquity of social learning among vertebrates (see review by Galef and Giraldeau, 2001), and its importance to the development of cattle foraging behaviour (reviewed by Miller-Cushon and DeVries, 2015), social learning may affect dairy cattle behaviour upon introduction to novel housing systems. Below is a brief overview of social learning including various definitions, mechanisms, and current evidence of social learning in cattle and other farmed animals.

1.2.1 Overview of social learning

Social learning is defined as learning that is influenced by observing, associating with or interacting with individuals and their products (Heyes, 2012). Learning from the experience of others can be more efficient than trial-and-error learning because animals learn behaviours that have been tested by others, which would have higher expected returns than untested behaviours (Smolla et al., 2015).

Social learning has many possible mechanisms. One of the simplest forms is local enhancement, where drawing attention to a particular location can make a foraging site features more prominent (Roberts, 1941). For example, the discovery of a food location attracts the attention of other group members, a phenomenon documented in birds (Krebs and Inman, 1992; Avery, 1994) and various mammals, including pigs (Nicol and Pope, 1994a).

Observational learning is defined as a change in behaviour following the observation of a conspecific performing a similar behaviour (Zentall, 2012). For example, newly hatched domesticated chicks, when observing pecking movements towards coloured plastic pin heads, peck disproportionately at pinheads of the same colour (Suboski and Bartashunas, 1984). Imitation is another mechanism of social learning, however it is difficult to show evidence for imitation as many field observations of supposed imitation have since been attributed to other forms of social learning such instrumental learning, stimulus enhancement, or even precise reinforcement by the researchers (Nicol, 1995). It should be noted that social learning decreases when the relative number of observers increases (Lefebvre and Giraldeau, 1996) and if demonstrators are not rewarded for their performance (Nicol and Pope, 1993).

1.2.2 Social learning in cattle and other farm animals

Older conspecifics can model important behaviours for younger individuals. In herbivores, social learning is important in developing foraging skills in young individuals (Launchbaugh and Howery, 2005). In cattle, the dam is the primary social model for her young (Hessle et al., 2009). However, it is common practice in the dairy industry to separate the calf from the dam at birth and further segregate animals based on age and milk yield (Grant and Albright, 2001). Fortunately, there is evidence that in the absence of parents other older conspecifics can also serve as social models for naïve individuals (Thorhallsdottir et al., 1990; Howery et al., 1998).

Evidence of potential social learning in cattle has recently emerged. For example, dairy heifers (Costa et al., 2015) and castrated male calves (Hessle, 2009) showed improved grazing activity when first introduced to pasture with an experienced social model. Heifers consumed a greater diversity of plant species in unfamiliar grazing sites when accompanied by an older conspecific (Velázquez-Martínez et al., 2010). Dairy calves have displayed increased feed intake and performance during the pre and post-weaning period when an older, weaned calf was present (De Paula Vieira et al., 2012a). Additionally, calves reared with older conspecifics showed reduced social reactivity to novel animals when compared to calves housed individually (De Paula Vieira et al., 2012b).

Cows and heifers that observe their neighbouring pen mates being handled adversely by a specific handler distance themselves from that handler, and conversely remain closer to handlers who treat neighbouring pen mates more gently (Munksgaard et al., 2001). Cattle are also sensitive to subtle visual cues; Coulon et al. (2011) found that cattle were able to discriminate between familiar and unfamiliar animals using only head cues represented in two-dimensional images. These findings suggest that cattle can distinguish subtle visual cues such as ear position (Coulon et al., 2011), are able to remember both positive and negative events, and may recognize individual people specifically (Munksgaard et al., 2001).

Evidence of social learning in other farm species has also been reported. Veissier and Stefanova (1993) found that interacting with an older lamb experienced at suckling from an artificial teat improved the use of artificial teats by naïve lambs. Nicol and Pope (1994a) reported that pigs showed significant bias towards searching and finding hidden food in the same container that a demonstrator had previously used. Nawroth et al. (2016) found that goats learned socially from humans, which improved their performance during a spatial problem-solving task. Additionally, there is evidence that chickens are proficient social learners based on their performance in various instrumental discrimination and observational learning tasks (Cronhelm, 1970; Johnson et al., 1986; Nicol and Pope, 1994b).

However, not all studies on social learning in herbivores have reported positive results. Naïve yearling steers did not display increased feeding site avoidance when accompanied by an older social model trained to avoid certain feeding sites (Cibils et al., 2008). Additionally, Veissier (1993) studied heifers that observed a trained heifer push a panel to open a box containing food pellets. While the observers were more likely to contact the box, they were not more likely to obtain the food reward compared to the control animals, suggesting that stimulus enhancement increased the observer's awareness of the box but not of the food reward housed inside (Veissier, 1993). Additionally, Baer et al. (1983) and Baker and Crawford (1986) reported negative results in horses during discrimination tasks where horses were required to obtain food from coloured buckets after watching demonstrator horses perform the task successfully.

1.2.3 Other social factors

Various other social considerations should be made when housing dairy cattle in indoor housing systems. Firstly, cattle form long-lasting social bonds from a young age (Gutmann et al., 2015), with cases of 'friendship' being documented in adult cattle (Sambraus, 1976). Secondly, allogrooming is a common form of social behaviour, and plays an important role reducing external parasites in cattle (Rich, 1973). Allogrooming is commonly viewed as a positive, affiliative behaviour in cattle indicative of friendship (Wasilewski, 2003; Boissy et al., 2007), with the intensity of allogrooming related the strength of the affiliative bond (Wasilewski, 2003). Tresoldi et al. (2015) reported that occurrences of both social licking and agonistic interactions were four times higher in freestall barns versus on pasture, likely due to the relatively smaller indoor space provided in the freestall housing. Interestingly, these authors argue that previous agonistic events did not predict future occurrences of social licking, or the role (groomer or receiver) of individual heifers.

Finally, dominance plays a role in social interactions, as aggressive interactions increase when subordinate animals are housed with dominant individuals at high stocking densities (DeVries et al., 2004) or when animals are forced to compete for a resource (feeder space: DeVries et al., 2005; Huzzey, et al., 2006, freestalls: Fregonesi et al., 2007b). However, Val-Laillet et al. (2008) found that cows that compete to access one resource will not always do so when accessing another resource, suggesting that success of dominance displays may depend on the individual cow's motivation to access a particular resource.

1.3 IMPLICATIONS FOR MOVING HEIFERS TO FREESTALLS

Housing cattle in freestalls involves numerous health, management and social considerations. Improved manure management and financial returns should be considered along with animal health and welfare in the calculus of any management decision. Given the tremendous challenges associated with freestall housing (e.g. lameness; Chapinal et al., 2013; hock injuries Barrientos et al., 2013) it is questionable why this housing system remains so prevalent from an animal welfare perspective. A promising housing alternative may be compost bedded packs, where manure is incorporated into the bedding material to promote natural decomposition (Barberg et al., 2007; Bewley et al., 2012). When housed in compost bedded packs cows are at lower risk of lameness (Barberg et al., 2007; Burgstaller et al., 2016) and have improved hygiene (Barberg et al., 2007; Shane et al., 2010; Black et al., 2013) versus in freestall barns and traditional open pack systems. Additionally, animals housed in compost bedded packs show reduced levels of mastitis and lower somatic cell counts (SCC) (Barberg et al., 2007; Black et al., 2013).

If freestalls are used, it is important to determine how best to habituate young stock that has no prior experience with this housing system (O'Connell et al., 1993; Kjæstad and Myren, 2001; von Keyserlingk et al., 2011). In stalls with ample space, not hindered by a restrictive neck rail and in which there is little or no competition for resources, it may be possible to use social models to ease the transition of moving naïve heifers (i.e. heifers who have not been housed in freestalls), into this housing system. Current literature suggests that dairy cattle are capable of receiving and integrating social information from older conspecifics in unfamiliar sites (Hessle, 2009, Velázquez-Martínez et al., 2010, Costa et al., 2015). This makes them suitable models for studying social learning in freestalls, and suggests that social learning may have the potential to improve lying behaviour in dairy heifers.

1.4 RESEARCH AIMS

The aim of this thesis was to assess the effects of introducing naïve heifers to freestalls with experienced social models familiar with freestall housing. I hypothesize that naive heifers accompanied with social models will show less undesirable alley lying behaviour and reduced disturbances to stall lying, standing and feeding behaviours when introduced to freestalls compared with naïve heifers with no social models present.

CHAPTER 2 – Social Models Improve Freestall Use in Naïve Heifers

2.1 Introduction

Freestall housing was invented to control cow defaecation behaviour and to reduce the cost of bedding and labour associated with open bedded packs (Bramley, 1962). The intention with this type of housing is to provide cows with a comfortable lying surface while restricting lengthwise and lateral movement and position (Ruud & Bøe, 2011). Today, 51.4% of large (>500 animals) dairy operations in the United States house lactating cows in freestall barns (USDA, 2016) and about 35% of operations in Canada make use of this type of housing system (Denis-Robichaud et al., 2016).

However, cattle may have difficulty transitioning to freestalls, resulting in increased occurrences of undesirable behaviours. Elevated standing times have been reported (von Keyserlingk et al., 2011), which increases the risk of cows developing lameness (Singh et al., 1993a) and claw lesions (Greenough and Vermunt, 1991; Leonard et al., 1996). Perching, where cows stand with only their front legs in the stall, also increases when heifers are moved to freestalls (von Keyserlingk et al., 2011), and this behaviour has been linked to claw lesions and lameness (Flower and Weary, 2002; Galindo and Broom, 2000). Additionally, stall refusal is common in heifers transitioning to freestalls (Kjæstad and Myren, 2001; von Keyserlingk et al., 2011) resulting in animals lying outside of the designated lying area. Lying in the manure alley can lead to an increased risk of developing intramammary infections (Breen et al., 2009) through reduced udder hygiene, which has been associated with increased rates of mastitis (Schreiner and Ruegg, 2003; Reneau et al., 2005). Cows normally avoid faeces when on pasture (Whistance et al., 2011), as faeces is a common vector for various pathogens and parasites (Hart, 1990; Daniels et al., 2001). Collectively, increased standing and perching behaviours contribute to reduced dairy cattle claw health while alley lying behaviour may lead to poor animal hygiene. Measures to reduce these undesirable behaviours would benefit both the animals and producers, and one such measure could be through utilizing social learning mechanisms.

Previous studies have investigated the effect of using older cows as social models. In the presence of older, experienced conspecifics, naïve dairy heifers (Costa et al., 2015) and beef steers (Hessle, 2009) showed increased initial grazing when first introduced to pasture, and heifers consumed a greater diversity of plants and shrubs in unfamiliar grazing sites when accompanied by social models (Velázquez-Martínez et al., 2010). The presence of an older, weaned calf lead to increased weight gain pre- and post-weaning, and stimulated feeding behaviour in younger dairy calves (De Paula Vieira et al., 2012a). Calves housed with older conspecifics were also less reactive to unfamiliar calves (De Paula Vieira et al., 2012b).

Social learning, the process through which individuals learn from others rather than through direct experience (Gariépy et al., 2014), and its role in the development of foraging behaviour has been studied in cows (Launchbaugh and Howery, 2005; Hessle, 2009; Costa et al., 2015) and other vertebrates (see review by Galef and Giralsdeau, 2001). The importance of the social learning process to learned herbivore behaviours suggests that social mechanisms may also affect heifer behaviour upon introduction to novel housing systems.

Previous research has investigated the challenges heifers face upon transitioning to freestall housing (O'Connell et al., 1993; von Keyserlingk et al., 2011), yet to our knowledge no previous studies have used older, experienced heifers to serve as social models during this transition. Therefore, the aim of this study was to investigate the effects of providing social models on occurrences of undesirable behaviours such as lying in the alley when naïve heifers are introduced to freestall housing. We hypothesized that naïve heifers introduced to freestalls would show less stall refusal behaviours and reduced disturbances to stall lying and standing behaviours when accompanied with a social model compared with naïve heifers with no model present.

2.2 Materials & Methods

This experiment was conducted between June and November 2016 at The University of British Columbia's (UBC) Dairy Education and Research Centre, located in Agassiz, British Columbia, Canada. All procedures were approved by the UBC Animal Care Committee (Protocol No A14-0245).

2.2.1 Animals

A total of 48 naïve Holstein heifers (mean ± SD age: 4.3 ± 1.2 mo) were randomly assigned to either the social model or control treatment, balanced for age. Social model pairs were provided with an older heifer social model, resulting in 12 control groups (two naïve heifers per group) and 12 social model groups (two naïve and one older heifer per group). Prior to the beginning of the experiment all naïve heifers had at least 3 wks of experience lying on the bedded pack and no experience lying in freestalls.

Potential social models were observed continuously via video for 72 h; models were selected if they: 1) were between 1-3 months older than the corresponding naïve heifers, 2) were never observed lying in the alley, lying backwards in a stall, or displacing other heifers from stalls, and 3) had lived in freestall housing for over two months. These older heifers averaged (± SD) 6.7 (± 0.8) mo in age.

2.2.2 Experimental Design

The experimental area consisted of two adjacent sawdust packs (4.8m x 12.2m; width x depth) with open lying areas, and two adjacent freestall pens (6.7 m x 12.2 m), located in a naturally ventilated wood-frame barn. The sawdust pack contained a standing alley (4.8 m x 3.1 m) that separated the bedded pack (4.8 m x 9.1 m) from the feeding area, which contained a 1.3 m-tall fixed feed barrier with slanted bars 25 cm centre-to-centre angled 60^0 from horizontal. The two adjacent freestall pens each contained 13 sand-filled stalls in 3 rows: 2 sets of 4 stalls plus 5 stalls in the back of the pens. Freestalls measured 0.9 m centre-to-centre and contained neck rails located 1.2 m from the curb. Freestall pens contained both a feed alley and a back alley (6.7 m x 3.1 m), and a 1.3 m-wide crossover alley that allowed movement between the two alleys. A moveable head-locking feed barrier (height: 1.2 m, width: 0.4 m centre-to-centre) was present in both freestall pens. All alleys were covered in texturized rubber and scraped with an automated scraper 6 times per day. All lying areas were cleaned once per day at 0900 h, and fresh bedding was added at the beginning of the experiment. Animals had *ad libitum* access to fresh water through a self-filling water trough located near the feed alley.

Orts were removed immediately before the once daily feeding, which took place at 0900 h. Fresh feed on a DM basis consisted of *ad libitum* access to fescue grass hay and 2.3 kg/heifer/d of textured calf starter (Hi-Pro Feeds, Ltd., Chilliwack, BC) top-dressed onto the hay. Textured calf starter contained 57.5 % concentrate pellets, 14% flatted barley, 13% flatted oats, 10 % steamrolled corn, and 3.5 % molasses. Feed was pushed up twice daily at 1500 and 2200h. All pens were lined with plywood barriers at a height of 1.5m to prevent visual and physical contact between treatments, with a 0.3 m gap from the floor to the bottom of the alley gates to allow the automated scrapers to move unimpeded.

Animals from both the social model and control treatments were simultaneously moved from their home pen and introduced to the open pack at 0900 h on day 1. Both treatments were kept on the bedded pack for 5 d, and social model and control animals were simultaneously introduced into separate freestall pens after the morning feeding between 0900 and 1100 h on d 6. Adjacent sawdust and freestall pens housed alternating social model and control treatments throughout the experiment. One group of animals (both social model and control treatments) was removed during the study due to illness, resulting in a total of 11 social model and 11 control groups.

Animals were recorded in their respective pens 24 h/d for 10 d using 2 cameras/pen (Panasonic WV-CP314 24V, Panasonic, Mississauga Ontario, Canada). Cameras were positioned 8 m above the centre of each pen, and red lights (100 W) were hung 8 m above each pen to facilitate infrared video recording at night. Heifers were photographed before the experiment to facilitate individual identification during video analysis.

Behaviours were recorded from video for the final 3 d of the baseline period and 4 d after introduction to freestalls. Video recordings were scanned at 5-min intervals, scoring lying, standing, feeding, perching, lying in the alley and lying backwards. Latencies to commence feeding and to lie down in a stall upon introduction to freestalls were also recorded.

2.2.3 Statistical Analysis

Data were averaged by group (n=11), and the effect of treatment on behaviour tested using the Proc Mixed procedure in SAS (Version 9.2; SAS Institute Inc., Cary NC) with an auto-regressive (1) co-variance structure specifying day as a repeated measure. A specified contrast was used to compare the average of the last 3 d in the sawdust phase (baseline period) with the first day heifers were moved to freestalls, and additional contrasts to compare the baseline with d 2, d 3 and d 4 in freestalls to test if behaviour returned to baseline. Perching, lying in the alley, and lying backwards were examined using the Proc Npar1way procedure in SAS (Wilcoxon Tail Test), and were examined across treatment (i.e. not by day) given the rarity of these behaviours.

2.3 Results

No difference in treatment or day x treatment interaction was observed for time spent feeding, standing, or lying on the bedded surface. Therefore, data from the two treatments will be presented as a combined average for these behaviours.

2.3.1 Time lying on the bedded surface

During the last 3 d when heifers were housed on the bedded pack (baseline period), average lying time (± SE) was 13.9 ± 0.6 h/d (Figure 2.1). During the first 24 h in freestalls, lying times decreased to 10.7 h/d ($F_{1, 116} = 54.3$, $P < 0.0001$). This difference decreased on d 2 ($F_{1, 116} = 16.08$, $P < 0.001$) and d 3 in freestalls ($F_{1, 116} = 8.65$, $P < 0.01$), and did not differ from baseline by d 4 in the freestall pen ($F_{1, 116} = 3.7$, $P = 0.06$).

2.3.2 Feeding time

Heifers fed for an average of 6.1 ± 0.4 h/d during the baseline period (Figure 2.1). Average feeding time declined to 4.9 h/d in the first day after moving to the freestall ($F_{1, 116} = 19.2$, $P < 0.0001$) but did not differ from baseline values by day 2 ($F_{1, 116} = 1.6$, $P = 0.2$, d 4: $F_{1, 116} = 0.1$, $P = 0.7$).

2.3.3 Standing behaviours

Average time heifers stood in the alley increased from 2.7 ± 0.4 h/d during the baseline phase to 4.9 h/d when moved to freestalls ($F_{1, 116}$= 67.1, $P < 0.0001$, Figure 2.1). This difference decreased on subsequent days (d 2: $F_{1, 116}$= 6.4, $P = 0.01$; d 3: $F_{1, 116}$ = 4.5, $P = 0.04$) and did not differ from baseline by d 4 ($P = 0.4$). Average time spent standing with 4 hooves on the bedding decreased from 1.1 ± 0.1 h/d during the baseline period to 0.5 h/d during the first 24 h in freestalls ($F_{1, 116}$= 38.1, $P < 0.0001$, Figure 2.1), and remained lower than baseline values during the remaining 3 d in freestalls (d 2: $F_{1, 116}$= 35.9, $P < 0.0001$, d 3: $F_{1, 116}$= 51.8, $P < 0.0001$, d 4: $F_{1, 116}$= 60.0, $P < 0.0001$). Perching behaviour increased to 0.6 h/d during the first 24 h in freestalls but decreased in subsequent days with no difference between treatments observed.

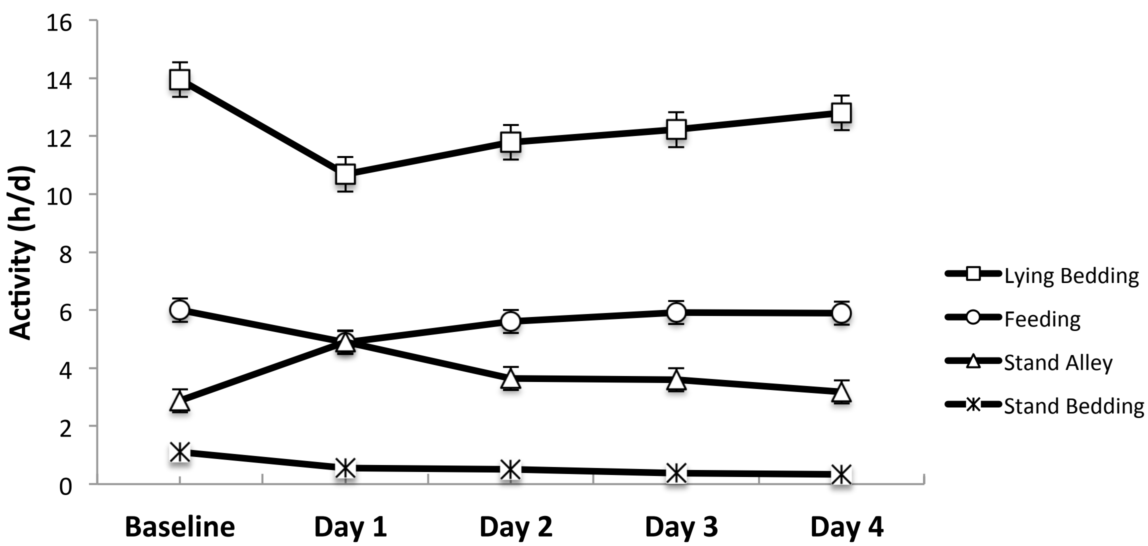

Figure 2.1 Combined mean (± SE) daily activity times of heifer pairs (n=22) in social model and control treatments showing time spent lying on bedding material, feeding, standing in the alley, and standing on bedding material while housed on the sawdust pack (baseline) and in freestall housing (Day 1 – Day 4). Baseline = average values from the last 3 days while housed on the sawdust pack.

2.3.4 Abnormal lying behaviours

While housed on the bedded pack, 2 of 22 heifers in the social model treatment and 8 of 22 heifers in the control treatment were observed lying in the alley. Upon introduction to freestalls 11 of 22 heifers in the social model treatment and 17 of 22 in the control treatment were observed lying in the freestall pen alleys (Figure 2.2). When moved to freestalls, heifers in the control treatment were more likely to lie in the alleys compared to heifers in the social model treatment (Wilcoxon one tail test = 154.5, p = 0.04). Lying in the alley was only examined during the freestall phase as this behaviour was rarely observed during the sawdust phase.

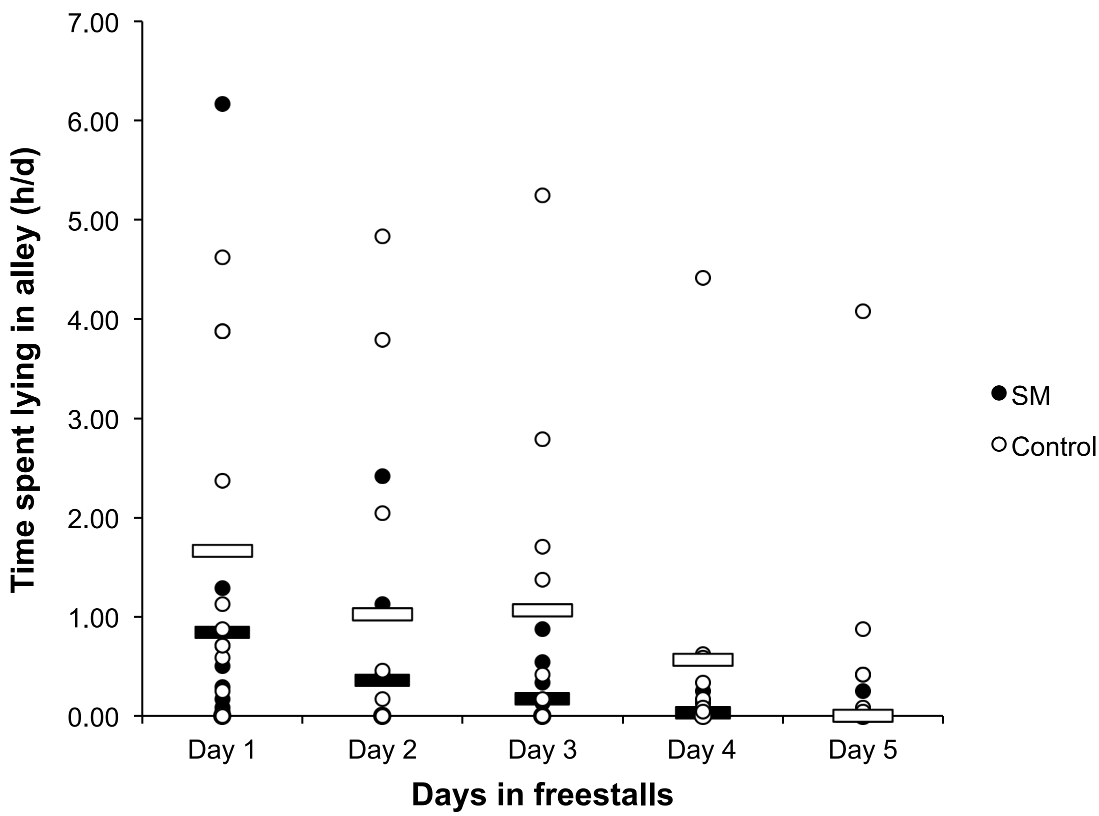

Figure 2.2 – Median time heifer pairs in the social model and control treatments spent lying in the manure alley (h/d) upon introduction to freestall housing (n=11 pairs/treatment).

Median time heifers spent lying in the alley was 0.8 h/d for the social model treatment versus 1.7 h/d for the control treatment during the first 24 hrs in freestalls (Figure 2.2). Alley lying was most prevalent during the first 24 h after introduction to freestalls, and on the second day in freestalls this behaviour decreased to median times of 0.4 and 1.0 h/d for social model and control treatments, respectively (Figure 2.2). On d 3, following introduction into the freestalls, median time spent lying in the alley had decreased to 0.03 h/d in the social model treatment, but remained at 1.1 h/d in the control treatment.

Additionally, 6 of 22 heifers from the social model treatment and 9 of 22 heifers from the control treatment were observed lying backwards in freestalls (Wilcoxon two tailed test = 136.5, $P = 0.5$). Two animals (one each from social model and control treatments) were observed persistently lying backwards during all 5 days in freestalls.

2.3.5 Latency to lie down and start feeding

Heifers varied in their latencies to first lie down, and to first visit the feeder when moved from the bedded pack to the freestalls (Figure 2.3). One heifer from each of the treatments lay down in the freestall within 30 min of introduction, but one heifer from the control group took over 30 h to first lie down in a stall. Similarly, 12 heifers from the social model group and 15 heifers from the control group began feeding within 5 minutes after the move to the freestalls, but 1 heifer from the control group took nearly 60 minutes to begin feeding.

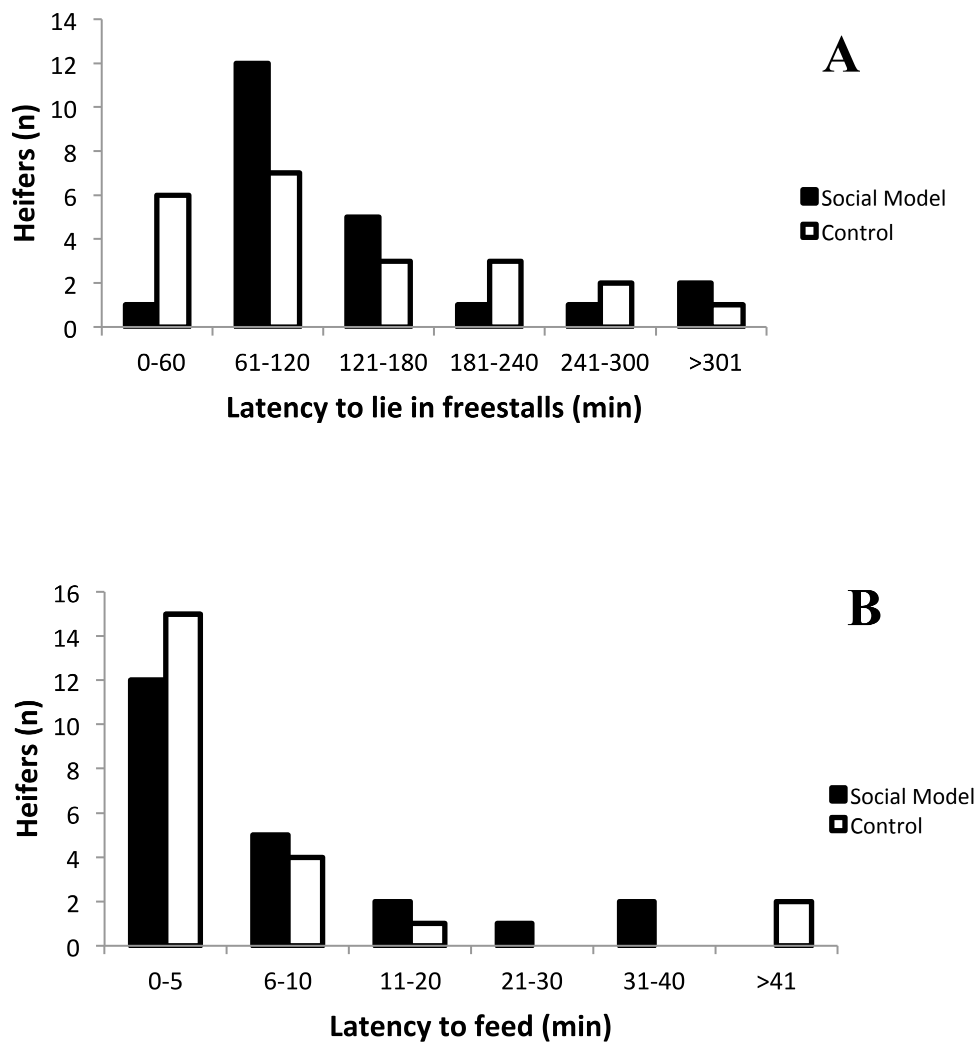

Figure 2.3 Frequency distribution of latency (min) to first lie down in a freestall (A) and start feeding (B) when heifers (n = 22) were introduced to freestall housing. Results are shown separately for heifers housed with a social model and control heifers with no model.

2.4 Discussion

Previous studies have investigated the effects of social models on bovine feeding behaviour (Hessle et al., 2009; Velázquez-martínez et al., 2010; De Paula Vieira et al., 2010a; Costa et al., 2015), yet to the best of our knowledge this is the first study to investigate the effects of social models when introducing naïve dairy heifers to freestall housing. Our findings are in agreement with von Keyserlingk et al. (2011) who found similar increases in average daily standing and perching times in addition to decreases in average daily lying times when heifers were first moved to freestalls. In the current study, a decrease in feeding time was observed during the first 24 h after moving heifers to freestalls. This decrease can likely be explained by an increase in the time heifers spent exploring the novel freestall environment. Munksgaard et al. (2005) found that lying is a higher priority behaviour than feeding, with cows reducing daily feeding time but maintaining daily lying times when either access to food or lying areas was temporally restricted. A reduction in feeding time occurs upon regrouping cows due to increased displacements at the feed bunk (von Keyserlingk et al., 2008), but the animals in the present study were not regrouped and displacements at the feed bunk were rare given the large area of feeding space available per cow.

Although our study showed no effect of a social model in reducing disturbances to standing and stall lying behaviours when naïve heifers were transitioned to freestalls, the results suggest that a social model may reduce occurrences of lying in the alley. Cattle normally synchronize their lying behaviour (Nielsen et al., 1997; Gygax et al., 2007) and have been reported to actively synchronize their posture with neighbouring pen mates (Stoye et al., 2012). Lying down is also considered a contagious behaviour in cattle (Benham, 1982). These findings suggest that, when introduced to freestalls, naïve heifers may synchronize lying behaviour and posture with that of the social model lying in a freestall. Conversely, alley lying may proliferate in freestall pens of only naïve heifers that observe one or more individuals displaying this undesirable behaviour. O'Connell et al. (1993) found that young heifers who lay in the alley were also more likely to do so one year later, while animals that successfully lay down in freestalls as young heifers continued to do so over the same period, providing some evidence that alley lying can persist long-term. Therefore, the use of social models may provide a practical option to reduce the risk of stall refusal in naïve heifers.

As suggested by Kjæstad and Myren, (2001) lying in the alley can contribute to reduced animal hygiene through increased contamination of the bellies and udders with faeces and urine. Indeed, Breen et al. (2009) found animals that lay in the alley were at increased risk of developing intramammary infections. Faeces contain potentially pathogenic bacteria such as *Escherichia coli* (Bramley and Dodd, 1984), and increased pathogen densities associated with faecal soiling of the udder may increase the risk of mastitis (Hogan et al., 1989). The animals in the current study were likely at minimal risk of exposing their udders to faeces and urine due to the low stocking density in the freestall pens (2-3 animals per 13 stalls); higher densities result in more faeces and urine in the alleys, a known risk factor for reduced udder hygiene (Ruud et al., 2010; Hauge et al., 2012).

While cattle do not display latrine behaviour (White et al., 2001), dairy calves have been successfully trained to urinate in a specific location through operant conditioning (Vaughan et al., 2014). When provided adequate space (e.g. on pasture), cows show clear faeces avoidance behaviour (Whistance et al., 2011). Expression of natural behaviour is one of three constructs of animal welfare (Fraser et al., 1997), and exposing cattle to conditions where they choose to lay in the manure alley versus a freestall may interfere with the expression of their natural faeces avoidance behaviour.

The results of this study align with research suggesting that older conspecifics can act as social models for young individuals (Thorhallsdottir et al., 1990; Howery et al., 1998). Experienced individuals often affect the foraging decisions and site selection patterns of younger herd members (Galef and Giraldeau, 2001; Launchbaugh and Howrey, 2005), and social influences may increase a young individual's fitness by influencing predator avoidance strategies (Galef and Laland, 2005) and improving foraging success in variable environments (Boyd and Richerson, 1983). The findings of the current research suggest that social influences may also play a role in the lying behaviour of younger individuals, although the extent and duration of these effects are unclear and are likely affected by the relative age of the social models and recipients. For example, heifers under 6 mo of age rarely exchange aggressive interactions and do not form clear social hierarchies versus more mature animals (Reinhardt and Reinhardt, 1982; Canali et al., 1986; Bouissou et al., 2001). Furthermore, younger heifers are not usually aggressive after regrouping compared with semi-mature cattle (Bouissou, 1974; Veissier et al., 2001). Therefore, social modelling may be most effective at a young age to minimize the potential interference of aggressive social interactions on social learning. Additionally, if social models are significantly older and larger than the recipients, physical interactions, including play behaviours and aggressive interactions, may carry increased risk of injuring the younger, smaller recipients.

In herbivores, social learning is an important factor in developing foraging skills in young individuals (Launchbaugh and Howery, 2005). While the findings of the current study suggest social learning played a role in reducing stall refusal in naïve heifers, the exact mechanism behind this observed difference is unclear. It is possible that, while lying correctly in freestalls, the social models drew the attention of the naïve heifers; suggesting observational learning and local enhancement may have played a role. Social facilitation may have enabled naïve heifers to lie down while observing the social models doing so. Naïve heifers may have also mimicked the behaviour of the social models. It is likely that the decreased stall refusal observed in the social model group was not the result of a single mechanism but a combination of many mechanisms working in concert. Future work is encouraged to further investigate the mechanisms by which social modelling occurs in dairy cattle, and the degree to which each mechanism affects learning outcomes.

Additionally, this experiment only recorded behaviour for 5 d when animals were moved to freestalls; it would be interesting to observe how long stall refusal behaviour persists in naïve heifers with and without social models present. Finally, future work is needed on how best to ease the transition of naïve heifers into freestalls to reduce disturbances to standing and lying behaviours. This could be achieved by gradually habituating heifers to freestalls by giving them access to both sawdust pack and freestall pens before transitioning to just freestalls. Such choice phases have been successfully employed during preference tests where cattle are provided both sawdust pack and freestall lying areas (Fregonesi et al., 2009b), or modifications to freestall components such as wet versus dry bedding (Fregonesi et al., 2007a) and the presence or absence of neck rails and side partitions (Abade et al., 2015).

2.5 Conclusions

Social models reduced occurrences of alley lying behaviour in naïve heifers during the transition to freestalls, and may represent a feasible solution to combat stall refusal when moving heifers to freestalls for the first time. Disturbances to feeding, standing and perching behaviours were observed in all heifers regardless of treatment, suggesting that the move from sawdust pack to freestalls is difficult for all heifers.

Chapter 3 – General Discussion

The objective of my research was to investigate the effects of providing naïve heifers with experienced social models when transitioning to freestall housing. In this chapter I will discuss my findings and how they contribute to the current literature on social learning in dairy cattle. I will also describe the strengths and limitations of my work, and suggest possible areas for future research on this topic.

3.1 Thesis findings

In Chapter 1 I reviewed the literature on factors that may affect lying behaviour in freestall housing, in addition to the health and management challenges associated with this housing system. Freestall housing is associated with higher prevalence of lameness (Chapinal et al., 2013) and hock injuries (Barrientos et al., 2013) versus open pack systems. Bedding quality (Fregonesi et al., 2007a), stall design (Tucker et al., 2004; 2006), stocking density (Fregonesi et al., 2007b) and regrouping (von Keyserlingk et al., 2008) can affect dairy cattle daily lying times. Additionally, reduced stall hygiene has been linked to higher incidences of mastitis (Hogan et al., 1989), a condition that also affects daily lying times (Fogsgaard et al., 2015). My review provided an overview of various social learning mechanisms and summarized evidence of social learning in dairy cattle. The presence of an older weaned calf reduces social reactivity (De Paula Vieira et al., 2012b) and increases feed intake during weaning in younger calves (De Paula Vieira et al., 2012a). Additionally, the presence of an older conspecific stimulates grazing behaviour (Hessle, 2009; Costa et al., 2015) and increased plant diversity consumption (Velázquez-Martínez et al., 2010) in naïve heifers when introduced to pasture. My thesis work now provides evidence that social learning may also improve freestall use in naïve heifers during the transition to freestall housing, specifically by reducing the likelihood that heifers will lie down in the manure alley.

In Chapter 2 I examined the effects of a provisional social model on naïve heifer behavioural responses to freestall housing. In support of my original hypothesis, naïve heifers housed with an older social model displayed reduced alley lying behaviour versus a control treatment with no social model. However, my findings did not support the hypothesis that social models would increase lying times, suggesting that this transition is disruptive to heifers regardless of the presence of a social model.

Similar to the findings of O'Connell et al. (1993), individuals that displayed alley lying behaviour seemed to do so persistently, at least over the duration of the current study. With the exception of one heifer in the social model treatment that was observed lying in the alley only on the last day of the experimental trial, all other heifers that lay in the alley at the end of the experimental trial also did so on earlier days. Animals lying in the alley hinder the movement of pen mates (Kjæstad and Myren, 2001), this area is unhygienic, and the surface is likely less comfortable for lying than that available in the stall. Additionally, it may be possible for animals lying in the alley to get caught and pushed by automatic floor scrapers. This author has first hand knowledge of an incident where this occurred, highlighting the potential hazard of heifers laying in alleys of barns that employ floor scrapers.

The findings of my research suggest that the presence of an older social model experienced with freestall housing affects the lying behaviour of naïve heifers during the transition to freestalls. While alley lying behaviour still occurred in the social model treatment, it was more common and persisted for longer in the control treatment. The exact mechanism of potential learning is unclear. Social facilitation, local enhancement, observational learning and imitation may have influenced the lying behaviour of naïve heifers in the social model group when introduced to freestalls. Social facilitation, whereby an individual stimulates the expression of a behavioural response of another animal (Weiss & Miller, 1971; Curtis & Houpt, 1971), would result in more naïve heifers lying in freestalls while observing social models doing so. Local enhancement, where drawing attention to a particular location can make site features more prominent (Roberts, 1941), may cause naïve heifers to spend more time investigating stalls that social models occupy.

Observational learning, a change in behaviour following the observation of a conspecific performing a similar behaviour (Zentall, 2012), would result in more naïve heifers lying in freestalls after observing social models lie correctly in freestalls. Finally, imitation of social model lying behaviour may result in naïve heifers mimicking the posture, position and orientation of social models when laying in freestalls, although imitation has been difficult to demonstrate in previous studies (see Nicol, 1995). Interestingly, I also observed interactions between the social models and naïve heifers that were lying in the alley; following these interaction, the naïve heifer would stand up from the alley and lie successfully in a freestall for the first time. These informal observations suggest that the treatment difference may have been due to active reinforcement by the social model that may have redirected the lying behaviour of naïve heifers.

The cause of stall refusal in naïve heifers is unclear and likely multi-faceted. The design of freestalls may affect use of these stalls as heifers may have difficulty navigating the side partitions and neck rails to fully enter a freestall. The bedding material may have also affected stall refusal as cows have been reported to lie in alleys when moved from freestalls with sawdust to sand-bedded freestalls (Manninen et al., 2002); future work should avoid confounding the effects of new bedding with the change to freestall housing. Additionally, lying in the alley may be a result of the naïve heifers preferring to lie in close proximity to their pen mates. Heifers were commonly observed lying in the alley close to the freestalls their pen mates were occupying despite ample empty stalls being available. When housed on the open pack heifers were commonly observed lying in contact with each other; the design of freestalls requires animals to lie in parallel and the placement of the lower portion of the side partition can prevent animals from contacting each other. The preference of some animals to remain close to their pen mates, or to lie in a certain orientation in relation to their pen mates, may explain some occurrences of alley lying seen in this study. Furthermore, although cows prefer deep-bedded stalls versus stalls with little or no bedding (Tucker et al., 2003), it is possible that some heifers actually found the manure alley more comfortable than the sand-bedded surface. Cows generally prefer cool lying surfaces during warm months (Wadsworth et al., 2015). The current study took place from May to November, and during the summer months there were some warm periods (maximum daily temperature during the study was 28 C^o). However, during the fall temperatures declined to a low of 8 C^o, and the alley lying persisted. It should also be noted that on two occasions heifers (one each from the social model and control treatments) were observed lying in the alley while still in the open pack holding area before their experimental trials; one observation was in mid-June (control animal) and the second in late October (social model animal).

3.2 Strengths & limitations

This thesis builds on past work investigating the effects of social models in dairy cattle (De Paula Vieira et al., 2012a; 2012b; Costa et al., 2015). A strength of this research is that it served, in part, as a replication study of von Keyserlingk et al. (2011), showing that moving heifers to freestalls affects lying and standing behaviours during the first 24-48 h after the transition. Another strength of this study is that heifers were not competing for resources while the experimental trials were being conducted; we provided over 3 times the recommended number of lying stalls (13 stalls for 2-3 animals) and feeding space (4.8 – 6.7 m for 2-3 animals) as per Canada's National Farm Animal Care Council (NFACC) recommendations of 1.2 animals per stall and 0.6m of linear feeding space per animal. While these conditions may not reflect the reality of pens with higher stocking densities, they allowed testing of the hypotheses in an environment where competition for feeding and lying resources were greatly reduced, minimizing the effects of these potentially confounding effects.

Heifers housed in adjacent experimental pens had no visual access to the other treatment due to plywood barriers placed between individual pens. A 0.3m gap from the alley floor to the bottom of the alley gate was maintained to allow the floor scraper to pass under the gate, but it is unlikely that heifers were able to observe individuals in the adjacent pen given the small space and low viewing angle of the gap. Heifers in adjacent pens did interact through sniffing and possibly touching noses. However, this behaviour was uncommon and only seen immediately after introducing naïve heifer pairs to the sawdust pack or freestalls, and thus likely had little to no effect on the outcome of this study.

The time heifers spent standing on the bedded surface decreased when moved to freestalls and did not return to baseline levels. This reduction may be explained in part by the difference in relative area of the bedding surface in the freestall versus sawdust pack pens; approximately 75% of the nearly 57 m^2 sawdust pack pen contained bedding material, but only 33% of the 81 m^2 freestall pens was bedded. Therefore, this reduction in standing time may reflect the smaller relative area of bedding surface in the freestall versus sawdust pens.

This study was conducted on a research farm where calves were raised in groups of 8-10 calves per pen until approximately 2 mo of age, and handled regularly by staff and researchers. However, approximately 70% of dairy calves in the United States and over 30% of calves in Canada are housed individually (USDA, 2016; Villettaz-Robichaud et al., 2016). Individually raised calves show reduced cognitive abilities and social resilience versus group raised calves (see review by Costa et al., 2016), and may not adapt to new environments as quickly. If this study were to be replicated using individually raised animals, it is possible that these animals may not respond to social models similarly.

Finally, discrepancy in the number of animals used in each treatment (2 naïve heifers in the control treatment versus 2 naïve and 1 older heifer in the social model treatment) may have affected the results. While it was possible to balance each treatment by number of animals (i.e. have 3 naïve heifers in the control treatment), I suggest that this might have represented a greater confounding effect. Stall refusal can be an uncommon behaviour (O'Connell et al., 1993; Kjæstad and Myren, 2001), and is more commonly displayed when heifers are first introduced to freestalls (von Keyserlingk et al., 2011). Therefore, having an additional naïve heifer per control treatment may have led to more occurrences of stall refusal in that treatment, thereby inflating stall refusal rates in the control treatment. Even if the extra animal was not considered in the data analyses, the behaviour of that animal may have influenced the behaviour of the other naïve control animals in that pen.

3.3 Future research

I encourage future work to investigate methods for reducing disturbances to standing and lying behaviours in naïve heifers during this housing transition, perhaps by gradually transitioning heifers from open pack to freestall systems. This could be achieved by giving heifers free access to both sawdust pack and freestall pens before transitioning them to strictly freestalls. Such choice phases have been successfully used during preference tests in cattle (Fregonesi et al., 2007a; Fregonesi et al., 2009b; Abade et al., 2015), and may ease the transition of naive heifers to novel housing and bedding materials.

The personalities of individual animals may also affect stall acceptance when introduced to freestalls. Kurvers et al. (2012) predicted that, in foraging animals, individuals that are more bold and exploratory are more likely to be leaders by searching for food instead of relying on others. In cattle, beef heifers that spent more time interacting with a novel object were more likely to be located at the front of the herd (Ramseyer et al., 2009), suggesting that more exploratory individuals are more likely to employ riskier foraging strategies, perhaps leading to increased foraging opportunities. When introduced to freestalls, bold and exploratory individuals may participate in more 'risky' behaviour: attempting to lie down in freestalls more quickly than shy or non-exploratory individuals. Although shy, immobile individuals tend to cope better under changing, unpredictable conditions, individuals with bold or exploratory traits are generally thought to cope better under stable conditions (Koolhaas et al., 1999; Coppens et al., 2010). Therefore, the transition from sawdust pack to freestalls may favour bold individuals who are better able to cope under stable conditions as transitioning to freestalls is a single event in an otherwise relatively stable environment in terms of access to resources such as feed, water and lying areas

Individuals employ different coping strategies in response to various stressors. Aggressiveness is one behavioural trait associated with a 'proactive' coping style, while shyness and immobility are associated with a 'reactive' coping style, (Koolhaas et al., 1999; Coppens et al., 2010). Individuals also differ in their level of fear and emotional reactivity when responding to stressful events (Koolhaas et al., 2007). More fearful individuals generally show stronger responses such as immobility or heightened levels of aggression, in addition to increased physiological activity in the sympathetic nervous system and hypothalamic-pituitary-adrenal axis (Boissy, 1995). Previous research has shown a high degree of individual variability in the physiological stress responses in cattle when first introduced to a novel feed lot environment (Loerch and Fluharty, 1999; Eitman et al., 2010), and in dairy heifers introduced to the milking parlour for the first time (Van Reenen et al., 2002). Future works should investigate how differences in behavioural and physiological responses, coping strategies and personalities affect stall refusal in naïve heifers, and how these factors may inform the selection of particular individuals to serve as social models for naïve individuals during the transition to freestalls.

Finally, while this research used a social model per pair of naïve heifers, it would be interesting to study the effects of social models at higher stocking densities, perhaps with multiple social models as social learning decreases when the relative number of observers increases (Lefebvre and Giraldeau, 1996). Therefore, future work should also investigate the threshold of effectiveness for a single social model relative to the number of naïve heifers present, and determine how many naïve animals can be housed in the presence of a single social model while still retaining the effect of reduced occurrences of stall refusal demonstrated in the current study

3.4 General conclusions

A social model reduced the likelihood of lying in the alley when naïve heifers were moved to freestalls. This result suggests that social models may be a practical solution for helping heifers adjusts to freestall housing. Future work should further investigate methods for reducing disturbances to standing and lying behaviour when naïve heifers are moved to novel housing systems.

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