Current research considering social behavior to improve welfare of commercially raised dairy calves

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Abstract: Social contact in early life has broad benefits for behavioral development and welfare of the developing dairy calf. The most accessible approach to providing social contact for commercially raised dairy calves is rearing calves in same age groups, a practice which is growing in popularity. This symposium review highlights developing areas of research relevant for widespread implementation of social housing on commercial farms. I discuss the onset of social behavior in young calves, development of social preferences, implications of calf management and housing for expression of social behavior, individual differences in social behavior, and implications of environmental complexity within the context of social housing. Under both naturalistic and commercial settings, calves interact socially within the first days of life, and develop preferences for familiar social companions. Early introduction to social housing appears to benefit the development of social behavior which may affect integration in later social groups, with potential long-term effects. Housing and management factors affecting socially housed calves have potential to disrupt social synchrony compared with behavior under more natural conditions, which can reduce social lying, cause competition for access to feed, and may have implications for social bond formation and social learning within the social group. While calves exhibit preferences for familiar individuals and motivation for social synchrony, social behavior is also widely variable between individuals and over time. Individual differences in social behavior may be attributed to personality as well as transient states such as disease or pain, and accommodating individual preferences for social interaction or isolation may be important within groups of larger calves. Throughout this paper, I contrast behavior of commercially raised calves in social housing with behavior of calves under more naturalistic conditions and address both short-term effects for calf development and potential longer-term implications for behavior and welfare. Welfare of commercially raised calves may be improved by refining social housing to better accommodate natural social behavior.

While the dairy industry continues to raise most calves without social contact during the first weeks of life, social housing for young calves is becoming more common. It is well established that housing calves with some type of social contact, compared with individual housing in early life, benefits calf development. Briefly, in terms of physical health and growth, housing young calves with at least one other calf stimulates solid feed intake and can improve weight gain, particularly during weaning (De Paula Vieira et al., 2010; Miller-Cushon and DeVries, 2016) without compromising health (reviewed by Costa et al., 2016b). There is also evidence to support benefits of social housing for affective state: for example, socially housed calves vocalize less in response to weaning (De Paula Vieira et al., 2010) and may have a more optimistic judgement bias (Bučková et al., 2019). These findings align with evidence across species of detrimental effects of social isolation for broad outcomes including social ability and anxiety (Arakawa, 2018), cognitive development (Kundakovic and Champagne, 2015), and health and longevity (Walker et al., 2012). Although there are varied approaches to rearing calves socially, including with the dam or a foster cow (reviewed by Johnsen et al., 2016), raising dairy calves with one or more similarly aged companions is the most widespread and accessible approach to accommodating social contact early in life, within the context of commercial dairy production today.

While social housing unequivocally offers welfare advantages compared with rearing calves in individual pens (reviewed by Costa et al., 2019), there are more nuanced questions of how to best accommodate social behavior to improve calf welfare in commercial social housing systems. In this review, I highlight recent research addressing key aspects of dairy calf social behavior and how they relate to environmental and individual factors relevant for commercially raised calves. This review first introduces early social interactions and establishment of social preferences in commercially raised dairy calves. Next, it encompasses current understanding of how common management factors (age of introduction, group composition, and housing environment) interact with the expression of social behavior, including formation of social preferences and behavioral synchrony. It then addresses how social behavior is subject to individual variability, and can relate to individual traits, including personality and health status. Finally, this review discusses broader environmental complexity within the context of social housing, with implications for learning, response to novelty, and development of abnormal behaviors. Throughout, this review considers both immediate effects and potential long-term implications for behavior and welfare and identify areas for future research. Given the brevity of this symposium paper, this is not a comprehensive literature review of work in this area, but a focused discussion of some of these developing areas of research. Where possible, I highlight recent research related to these topics and discuss promising directions for further research to better understand social behavior and improve the welfare of dairy calves.

Considering that I have subjectively chosen the focus of this short narrative review as the single author, I will include a positionality statement (Ritter et al., 2023), to provide context for how...
my personal experiences and values may influence perception and investigation of this topic. I am an associate professor at the University of Florida with a research and teaching appointment in animal behavior and welfare. Although I grew up in a rural area with some exposure to animal agriculture, I only began academic study of dairy science during graduate school at the University of Guelph. During this time, I researched factors influencing dairy calf behavior and welfare while interacting with students and faculty interested in improving animal welfare across species. This experience shaped my perspective that opportunities for natural, motivated behaviors are a requirement for good animal welfare.

While approaches to housing calves socially on commercial farms are definitively different from cattle social groupings under natural conditions, there are some parallels in the expression of social behavior. Under natural conditions, while maternal contact and mother-daughter bonds are critical (Reinhardt and Reinhardt, 1981), calves also interact in same age social groups from a young age. There are reports of large groups resting apart from the dam (Maremma cattle; (Vitale et al., 1986) and in small newborn groups under cooperative maternal care (zebu cattle; (Orihuela et al., 2021). For example, Maremma cattle spent over 70% of their time away from the dam, socializing with other calves, before 10 d of age (Vitale et al., 1986). Commercially raised dairy calves housed in similar age groups perform social play and allogrooming (reviewed by Costa et al., 2019), key affiliative behaviors that are also observed under naturalistic conditions (Vitale et al., 1986). Social sniffing and licking has been reported at only 2 d of age in pair-housed calves, with calves spending hours of their day engaged in social behavior with their penmate within a few weeks (Duve and Jensen, 2012). Within the first weeks of life, calves are also motivated to access even an unfamiliar calf, pushing a weighted gate to access social contact (Ede et al., 2022). Social contact thus appears important for commercially raised calves from a young age.

Evidence across species suggests that the quantity and quality of social relationships influence individual stress and health status (Cohen, 2004) such that opportunity to form social bonds may be an important predictor of welfare. The formation of social bonds is evident in semi-wild herds of cattle exhibiting persistent preferences for specific social partners when grazing and grooming (Reinhardt and Reinhardt, 1981). Studies of dairy calves separated from the dam at birth also suggest the formation of social preferences between same age calves that are housed together. Pair housed calves spent more time near their penmate in a social preference test conducted in a novel arena, with no evidence of social preferences between calves reared in adjacent individual pens (Lindner et al., 2022). Calves housed within the same pen also had greater behavioral synchrony than calves in adjacent individual pens (Duve and Jensen, 2012). Calves raised in pairs prefer to be near their former penmate following introduction to larger groups (Zhang et al., 2022; Lindner et al., 2021). In group-housed calves, the presence of a familiar calf reduces behavioral indicators of fear in an unfamiliar environment (Færevik et al., 2006), supporting the importance of social relationships for welfare. While the persistence of social preferences arising from early social interaction has received limited study, Raussi et al. (2010) found that calves spent the most time near calves they were introduced to in the first weeks of life, and these preferences persisted for over a year implying the formation of social bonds. Studies of social behavior in adult cows also suggest the formation of social bonds with individuals born around the same time, based on increased social grooming (Sato et al., 1993), closer social proximity (Gutmann et al., 2015), and greater behavioral synchronicity (Gygax et al., 2010).

While social experience under natural settings involves early interaction (Vitale et al., 1986) and opportunities to learn from more experienced social companions (Galef and Laland, 2005), social development in commercially reared calves is subject to age range within the group and timing of grouping. Exposure to an older social model has been found to reduce reactivity to unfamiliar calves (De Paula Vieira et al., 2012b), suggesting that provides social benefits. More experienced social models also benefit social learning, stimulating solid feed intake in young calves (De Paula Vieira et al., 2012a), and influencing foraging behavior in weaned heifers upon introduction to pasture (Costa et al., 2016a; Arrazola et al., 2020). Limited additional work has considered social learning benefits of heterogenous age groups within the context of commercial social housing systems. Preferential relationships are more likely to occur between similar age calves in natural settings (Reinhardt and Reinhardt, 1981) and group-housed calves in mixed-age groups also prefer resting next to same age calves (Færevik et al., 2010), suggesting that contact with more experienced role models may be less related to social bond formation in young calves.

Early social development and opportunity for social bond formation is likely to depend on age of introduction to social housing. For example, Duve and Jensen (2011) describe evidence of preference for a penmate from birth in social preference tests at 5 weeks of age, whereas calves paired at 3 weeks of age had no preference. Other welfare benefits are associated with earlier introduction to social housing, including increased play and reduced vocalizations throughout the pre-weaning period (grouped at 3 or 7 d vs. 14 d; Abdelfattah et al., 2018) and reduced vocalizations at weaning (grouped at 5 vs. 28 d; Bolt et al., 2017). Some studies have found that preference for social companions in the first weeks of life may be transitory, but early socialization may provide other social benefits. Bolt et al. (2017) found that calves housed in pairs for 5 d before grouping reduced time with their former penmate during the weeks following grouping. Similarly, Lindner et al. (2021) found that calves housed in pairs from birth spent more time lying near their former penmate when initially moved to group pens at 2 weeks of age, but preferences did not persist after regrouping one week later. However, when exposed to a regrouping event a week later, previously pair-housed calves had greater total lying time and social rest, even in the absence of a specific preference for their former penmate, suggesting that earlier introduction to social housing may facilitate ability to integrate in novel social groups. More generally, early introduction to social housing may prevent negative effects of early social isolation on the development of social behavior, which are well-established in other species (e.g., impaired social recognition in rodents; (Arakawa, 2018). While social housing can improve ability to cope with social regrouping compared with individual housing (reviewed by (Bøe and Færevik, 2003), there are gaps in knowledge of how age of introduction to social housing affects longer-term social behavior. However, Wagner et al. (2012) described effects of maternal contact during the first 12 weeks of life on social differences in adulthood, including increased display of submissive postures which they suggest may improve ability to integrate in social groups.
Housing factors affecting commercially raised calves may constrain and influence social interactions, including proximity to specific partners and behavioral synchrony, in ways which differ from naturalistic settings. For example, lying synchrony decreases with more restrictive space allowances in group-housed calves (Faerevik et al., 2008) and upon movement from pasture to an indoor barn in weaned heifers (Raussi et al., 2010). These environmental factors affecting preferred social interactions may have implications for how we interpret social behavior. Lecorps et al. (2019) described limitations of interpreting lying social proximity as an indicator of social preference when animals are housed in free stalls which restrict lying options and afford less opportunity for individual selectivity in neighbors than an open bedded pack. Synchronous grazing is also evident between preferred social partners under natural conditions (Reinhardt and Reinhardt, 1981), and commercially raised calves also appear motivated to feed socially, having implications for competition. For example, pairs of milk-fed calves will maintain synchronized meals when offered a single teat providing milk ad libitum, despite initiating and receiving frequent competitive displacements when not able to feed simultaneously (Miller-Cushon et al., 2014). Similarly, decreasing the number of available teats causes calves to consume less milk and displace each other more frequently, even when the group size is small and milk is available ad libitum (von Keyserlingk et al., 2014). Competitive pressure for access to milk also results in greater rates of intake (coinciding with larger group sizes; Dong et al., 2017; Jensen and Budde, 2006). Competition in group-housed calves fed simultaneously with multiple feeding spaces (e.g., a teat bar or mob feeder) is exacerbated by teat switching, a natural behavior coinciding with reduced milk flow during suckling (de Passillé and Rushen, 2006), which may be reduced by barriers between feeding spaces (Jensen et al., 2008). Feeding synchrony is effectively eliminated through provision of milk autofeeders, which accommodate one calf at a time and can reduce displacements (O’Driscoll et al., 2006). However, calves wait to access the feeder, especially when housed in larger groups (Jensen, 2004), suggesting that they remain motivated to feed socially or are experiencing a degree of competition which constraints preferred feeding patterns. Concern has been raised surrounding high autofeeder stocking densities (e.g., 40 calves per feeder; Brscic et al., 2009), which restrict access to the feeder and may limit intake and increase cross-sucking.

Preference for social synchrony surrounding solid feed consumption has been less studied in young calves, although weaned calves prefer feeding next to familiar animals, even when feeding spaces were restricted to elicit competition (Miller-Cushon and DeVries, 2016). Social synchrony and proximity in young ruminants influence opportunities for social learning about feed (Galef and Lal-and, 2005), such that social contact increases consumption of novel solid foods (Whalin et al., 2018) and meal frequency of both starter and milk (Miller-Cushon and DeVries, 2016). These beneficial effects are enhanced through access to older animals (e.g., weaned heifers; De Paula Vieira et al., 2012a), although age heterogeneity in groups of pre-weaned calves may increase competition for milk and negatively affect performance (Faerevik et al., 2010). These social influences on feeding, including learning about solid feed and improving competitive success (Suchon et al., 2023; Duve et al., 2012), have potential to mediate longer-term differences in growth of developing dairy heifers. In general, managing calves to accommodate behavioral synchrony allows expression of social preferences, opportunity for social learning, and reduces competition.

While socially housed calves generally exhibit preferences for social synchrony and proximity to familiar animals, social behavior is also subject to individual variability. Within-group individual variability in social behavior is evident across species and has been attributed to a variety of factors, including personality (i.e., individual differences in animal behavior which are consistent across time and context; Kaiser and Müller, 2021). There is evidence to suggest that a bidirectional relationship exists between position within a social network and an individuals’ personality, such that an animal’s social position may be influenced by their personality, but social experience may also shape personality, particularly in juveniles (Krause et al., 2010). In dairy calves, Lecorps et al. (2019) described individual variability in selectivity of social partners, with an association between social avoidance and pessimism. Consistency of individual differences in social behavior over time has received limited study in dairy calves, although some evidence suggests that centrality in social networks is repeatable across time periods during the pre-weaning and early post-weaning stage (Burke et al., 2023). Adding physical complexity may provide opportunities for individuals to express preferences for social engagement or isolation which mirror more natural environments, including the use of forms of physical separation or a ‘hide’ (reviewed by Spitzer et al., 2022). In group-housed dairy calves, use of a 3-sided physical shelter in the pen was highly variable between individuals, but consistent between individuals over a 3 d observation period (Gingerich et al., 2020). Opportunity to express individual preferences for social behavior may be an important welfare consideration for group-housed calves which warrants further study.

Variability in social behavior between individuals and over time may also be subject to transient internal factors, including health. For example, social withdrawal is commonly described as a component of sickness behavior across species (Dantzer, 2009). In dairy calves, disease has been associated with reduced social behavior, including reduced durations of social grooming and social lying (Hixson et al., 2018), reduced social play (Bertelsen and Jensen, 2019), and reduced centrality in social networks based on frequency of social contacts (Burke et al., 2022) and social proximity (Vázquez-Diosdado et al., 2023). Social connectedness may also relate to disease risk (e.g., e. coli colonisation in group-housed dairy calves was associated with active social interactions; Tamminen et al., 2020). Individual social behavior may also respond to pain. Following disbudding, group-housed dairy calves increased use of a physical shelter and were more likely to enter it when it was unoccupied (Gingerich et al., 2020), potentially reflecting motivation for isolation or physical protection. Evidence in other species also suggests that the relationship between individual emotional state and social behavior may depend on social context (e.g., primates seeking comfort from a familiar companion following an experimental infection; Willette et al., 2007), suggesting that social changes in response to pain or disease may depend on existing social relationships. Exploration of the relationship between social interactions and individual attributes in future work may be facilitated through the increasing availability of technology to monitor social behavior and proximity (including location track-
ing systems and computer vision) which may lay groundwork for novel behavioral indicators of animal welfare.

In addition to accommodating aspects of natural social behavior, social housing for commercially raised calves provides broader opportunities for environmental complexity. Some aspects of environmental complexity are intrinsic to social housing, such as added space and interaction with other calves, while other additional resources may become more feasible or cost-effective to provide in conjunction with social housing, such as rotating brushes to stimulate grooming (Horvath and Miller-Cushon, 2019a). Some established benefits of social housing for young calves, including easing adaptation to novel environments, improving cognition, and reducing abnormal behavior, may be enhanced by broader consideration of environmental complexity. First, social contact is known to lessen behavioral and physiological indicators of fear when faced with novelty, across species (reviewed in rodents by Arakawa, 2018) including calves (Jensen et al., 1997). Latency to contact a novel object is reduced in pair-housed calves, compared with individually housed calves (De Paula Vieira et al., 2012b; Meagher et al., 2015), and within group-housed calves, those animals pair-housed from birth were less avoidant than animals individually housed for 2 weeks before grouping (Gingerich et al., 2023). However, more extensive studies in rodents suggest that novelty exploration is related to the complexity of the rearing environment, apart from social stimulation specifically (Zimmermann et al., 2001). This is supported in dairy calves by findings that pre-weaning physical enrichment (stationary brushes, objects for oral manipulation, and scented hay in nets) increased social sniffing and exploration of the environment during post-weaning grouping, whereas pair-housing compared with individual housing with physical contact did not (Zhang et al., 2022). Welfare of commercially raised calves is therefore likely to be improved by considering opportunities for increased behavioral expression in conjunction with social housing.

It is well established in other species that early environmental complexity in general influences neurological development and can improve cognitive ability (Lewis, 2004). Social housing can improve cognitive flexibility of dairy calves, with pair housing improving reversal learning ability in a visual go/no go task (Gaillard et al., 2014; Meagher et al., 2015). Further, late pairing at 6 weeks of age had intermediate effects, with interestingly no difference between calves paired early at 6 d of age and calves reared with the dam (Meagher et al., 2015). In addition to social housing, other aspects of the calf rearing environment, including dietary complexity (e.g., hay provision; Horvath and Miller-Cushon, 2020) may improve cognitive flexibility. There is also evidence of improved object recognition memory associated with both social housing (Gaillard et al., 2014) and physical enrichment in the absence of effects of social contact (Zhang et al., 2022). Effects of social housing on cognition may depend on the nature of the task, as it is sometimes reported that socially isolated animals increase exploration of a testing environment, which may facilitate solving of certain cognitive tasks (e.g., see Fei et al., 2019). Long-term effects of early environmental restriction, including social isolation, on cognitive outcomes are established in other species (reviewed by Kundakovic and Champagne, 2015) but remain unreported in dairy cattle. While some evidence in other species suggests that cognitive and behavioral differences arising from early social isolation may be reduced through later enrichment or social grouping, this varies between studies and may depend on the timing of social isolation (Hol et al., 1999).

In addition to influences on cognition and response to novelty, environments which restrict opportunities for motivated behaviors may give rise to abnormal behaviors. Dairy calves are highly motivated to suckle, and insufficient opportunity for natural suckling behavior leads to abnormal oral behaviors including pen-directed sucking, tongue play and rolling, and cross-sucking in socially housed calves. While the performance of these behaviors is closely tied to hunger and suckling opportunities, they are also reduced through behavioral opportunities including those that promote oral manipulation (hay provision; Downey and Tucker, 2023; Horvath and Miller-Cushon, 2019b) and other forms of stimulation, including brush provision (Horvath et al., 2020). Abnormal oral behaviors also occur more in individually housed, including, even when accounting for cross-sucking in pair housed calves (Doyle and Miller-Cushon, 2023). The degree of social isolation may also play a factor, as individual housing with visual isolation increased pen-directed non-nutritive sucking compared with calves housed individually with visual contact or socially, although cross-sucking occurred in socially housed animals (Jensen et al., 1999). Both physical enrichment and pair housing have been found to reduce pen-directed non-nutritive sucking (Zhang et al., 2021) and physical enrichment allowing oral manipulation reduced cross-sucking in group-housed animals (Salter et al., 2021; Zhang et al., 2021), suggesting that environmental complexity of socially housed animals can mitigate development of abnormal oral behaviors.

Calf management decisions are increasingly being made in consideration of dairy calf behavioral needs, in response to widespread concern for animal welfare. Group housing dairy calves may be viewed more positively by the public than individual housing (Perttu et al., 2020), although concern surrounding maternal separation may still threaten social sustainability of the dairy industry (Sirovica et al., 2022). Research to date suggests that socially housed dairy calves should be managed to accommodate preferred social interactions and behavioral synchrony, which supports the development of social bonds and other benefits of social contact, including social learning. In the absence of providing maternal contact, this may be best achieved by mirroring aspects of natural social behavior: small groups of similarly-aged age calves, housed from birth in physically complex environments which allow for individual expression of social preferences. While further research linking early life management with long-term behavior and welfare outcomes would be beneficial, social housing and environmental complexity more generally provide cognitive and behavioral benefits in early life with no evidence of detrimental effects. Given the multitude of challenges experienced by a growing dairy heifer, including changes in housing and management, her behavioral and cognitive ability to adapt to novel environments and cope with social stressors may be a strong predictor of welfare.

References


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Notes

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