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## Invited review: Effects of group housing of dairy calves on behavior, cognition, performance, and health

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### ABSTRACT

Standard practice in the dairy industry is to separate the calf and dam immediately after birth and raise calves in individual pens during the milk-feeding period. In nature and in extensive beef systems, the young calf lives in a complex social environment. Social isolation during infancy has been associated with negative effects, including abnormal behavior and developmental problems, in a range of species. Here, we review empirical work on the social development of calves and the effects of social isolation in calves and other species; this evidence indicates that calves reared in isolation have deficient social skills, difficulties in coping with novel situations, as well as specific cognitive deficits. We also review the practices associated with group housing of dairy calves, and discuss problems and suggested solutions, especially related to cross-sucking, competition, aggression, and disease. The studies reviewed indicate that social housing improves solid feed intakes and calf weight gains before and after calves are weaned from milk to solid feed. Evidence regarding the effects of social housing on calf health is mixed, with some studies showing increased risk of disease and other studies showing no difference or even improved health outcomes for grouped calves. We conclude that there is strong and consistent evidence of behavioral and developmental harm associated with individual housing in dairy calves, that social housing improves intakes and weight gains, and that health risks associated with grouping can be mitigated with appropriate management.

**Key words:** social isolation, individual housing, replacement heifers, neonate development

### INTRODUCTION

Infancy is one of the most important periods of development for mammals, with the environment playing a crucial role (see review by Bornstein, 1989). The

detrimental effects of maternal separation and social isolation during infancy have been studied in a range of social species, including rodents (Heim et al., 2004), primates (Harlow et al., 1965), and humans (Troller-Renfree et al., 2015). Negative effects of social deprivation early in life have been shown in adulthood, which include impaired maternal care (e.g., Lovic et al., 2011), increased aggression (e.g., Toth et al., 2011), and impaired social recognition (e.g., Lukas et al., 2011).

Most farmed mammals (e.g., sheep, pigs, horses, and beef cattle) are housed with their dam during the milk feeding period, and the young normally also have contact with conspecifics of similar age. Dairy cattle production is the exception; standard practice within the industry is to separate calves from the dam soon after birth and raise calves in individual pens during the milk-feeding period (USDA, 2008; Vasseur et al., 2010). This limited maternal and social contact is in contrast to what occurs under natural conditions (Reinhardt and Reinhardt, 1981).

To our knowledge, no attempt has been made to summarize the available scientific information on the effects of social isolation on calves. This review describes the research to date assessing the role of isolation and social housing on calf development. We begin with a brief account of social development in natural settings when cows rear their young. We then review the literature on cattle and other species describing the effects on neonates of maternal and other types of social deprivation, and where applicable, draw from theories based on the human and laboratory animal literature. Finally, we discuss the group housing literature, describing challenges and successful practices associated with social housing of dairy calves. Where possible, we include recommendations for future research and considerations for application on farms.

### SOCIAL DEVELOPMENT IN CALVES

Shortly before parturition, cows tend to separate themselves from the herd and give birth in a secluded area (Lidfors et al., 1994). Once the calf is born, a series of maternal behaviors are observed, including licking

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of the calf and specific vocalizations (reviewed by von Keyserlingk and Weary, 2007). The dam normally keeps the young hidden in bushes or tall grass for the first few days while she forages nearby (Langbein and Raasch, 2000). The newborn calf is fully dependent on the milk provided by the dam and will nurse approximately 8 to 12 times daily during the first week of life, with each suckling bout lasting approximately 10 min (e.g., Reinhardt and Reinhardt, 1981; Day et al., 1987; Lidfors, 1996).

After several days, the calf and mother reintegrate into the herd (Bouissou et al., 2001). During the second week of life, the calf starts to increase the distance from the dam, begins interacting with peers, and may form small groups with other calves (Vitale et al., 1986; Sato et al., 1987). These calf groups also interact with older animals, and it has been reported that adolescents and adults without newborn calves will graze close to calf groups (e.g., Sato et al., 1987; Murphey and de Moura Duarte, 1990). This suite of characteristics and behaviors are also observed in other ungulates such as caribou (*Rangifer tarandus*; Rettie and Messier, 2001) and moose (*Alces alces*; Bowyer et al., 1999).

Under natural or semi-natural conditions, grazing ruminants select their diets from a wide variety of plants differing in nutritional composition and availability (Provenza and Balph, 1987; Baumont, 2000). Calves that are reared with their dam and other conspecifics start grazing and ruminating at approximately 3 wk of age and graze regularly with the herd at 3 to 6 mo of age (Reinhardt and Reinhardt, 1981; Vitale et al., 1986). The social interactions of young ungulates are associated with learning to recognize suitable diet and habitat, where selection happens through the mimicking or imitation of social companions (i.e., Key and MacIver, 1980; Mirza and Provenza, 1992, 1994). The progression from maternal care to independence is an important period of learning for young foragers (Provenza and Balph, 1987), making social partners important influences on diet selection for young ruminants (Nolte et al., 1990; Provenza et al., 2003).

Social learning allows individuals to learn from the positive or negative effects on another individual (Bandura, 1977; Conte and Paolucci, 2001); this type of learning is thought to be important in the development of feeding behavior in many farmed species (Keeling and Hurnik, 1996; Launchbaugh and Howery, 2005). Naïve dairy heifers show a more rapid onset of grazing when introduced to pasture with experienced social companions (Costa et al., 2016). Social learning theory suggests that the most effective social models are the dam and dominant peers (Bandura, 1977). Herbivores that feed in large mixed-generation groups, like cattle,

are able to use social learning to transmit information about suitable food items from experienced to inexperienced foragers (Boyd and Richerson, 1996).

Food neophobia is well known in ruminants (Chapple and Lynch, 1986) and is defined as avoidance and reluctance to taste unfamiliar foods (Cooke et al., 2006). Food neophobia is known to decrease in the presence of companions in lambs (Nolte et al., 1990) and when dairy calves are raised in complex social groups (Costa et al., 2014). In nature, young ruminants must learn how to select and eat appropriate foods (Freeland and Janzen, 1974); social learning enables an inexperienced animal to avoid the inefficiency and risk of testing each novel feed type, because the “trial-and-error” strategy could lead to the ingestion of toxic feed (Galef and Laland, 2005; Nicol, 2006).

In summary, young ruminants naturally form social relationships starting with the dam and then with other individuals, even in the first weeks of life. During the milk-feeding period, the calf relies on social cues from the dam and other conspecifics that influence behavioral development. Given that most dairy calves are separated from their mothers at birth and reared individually [e.g., 77% in the United States (USDA, 2008); 88% in Canada (Vasseur et al., 2010); 70% in Brazil (Hötzel et al., 2014)], numerous questions arise regarding potential negative effects of social isolation on social and feeding behaviors and other aspects of development. In addition to the effects outlined above, the results from several species suggest that social isolation may have important effects on cognitive development, as described below.

#### EFFECTS OF SOCIAL ISOLATION: EVIDENCE FROM OTHER SPECIES

There is considerable variation within the literature in what is called “social isolation,” ranging from complete isolation for extended periods (e.g., Sackett et al., 1981) to 2 h daily during the second week of age (Tuchschere et al., 2006). Social isolation was defined by Gottman (1977) as an absence or low frequency of peer interaction during an extended period. This definition applies to most dairy calves during the milk-feeding period and will be used in this review.

Bowlby (1969) famously described how events during childhood in humans have profound influences on behavior, even as adults. Individuals who experience social isolation or social deprivation during childhood tend to have psychological and behavioral disorders later in life, such as a greater tendency to develop schizophrenia (Rutter, 1979) and to express violent behavior and abnormal emotional responses (Bowlby, 1969). Some

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