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Invited review: Environmental enrichment of dairy cows and calves in indoor housing

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ABSTRACT

In recent years, an increasing number of farmers are choosing to keep their cows indoors throughout the year. Indoor housing of cows allows farmers to provide high-yielding individuals with a nutritionally balanced diet fit for their needs, and it has important welfare benefits for both cows and their calves, such as protection from predators, parasites, and exposure to extreme weather conditions. However, it also confronts cows and calves with a wide range of environmental challenges. These include abiotic environmental sources of stress (e.g., exposure to loud and aversive sound) and confinement-specific stressors (e.g., restricted movement and maintenance in abnormal social groups). Cows and calves that live indoors are also faced with the challenge of occupying long periods with a limited range of possible behavioral patterns. Environmental enrichment can improve biological functioning (measured as increased lifetime reproductive success, increased inclusive fitness, or a correlate of these such as improved health), help animals to cope with stressors in their surroundings, reduce frustration, increase the fulfillment of behavioral needs, and promote more positive affective states. Here, we review recent findings on the effect of social, occupational, physical, sensory, and nutritional enrichment on dairy cows and calves, and we assess the appropriateness and practicality of implementing different enrichment practices on commercial dairy farms. Some of the enrichment methods reviewed here may also be applied to those more extensive cattle-raising systems, where similar challenges occur.
Key words: social enrichment, zero grazing, animal welfare, low resilience behaviors

INTRODUCTION

Almost all dairy cattle are housed indoors, at least for some part of their life, and, in an increasing number of farms, indoor housing is practiced year round (Van Vuuren and van den Pol-van Dasselaar, 2006; Winsten et al., 2010; March et al., 2014). In continuous indoor housing systems (also referred to as "zero-grazing" systems), dairy cows are kept throughout the year in tiestall, freestall, or loose-housing cowsheds. Access to pasture is either limited or absent. In the past, continuous indoor housing of dairy cows was practiced mainly in regions where the climate was unsuitable for growing grass or too harsh for the animal. Today, with the gradual shift toward intensified farming, year-round housing is more widely practiced. It was recently estimated that zero-grazing housing will become the most prevalent farming practice in northwest European countries, such as northwest Germany and Denmark, by the next decade (Reijs et al., 2013). For example, in the Netherlands, the number of dairy cows housed indoors has tripled in the past 10 yr (from 10 to 30%; CBS, 2015). In the United States, more than 95% of lactating cows are denied access to pasture (NAHMS, 2010). Other Mediterranean countries, such as Israel, now keep 100% of their dairy cows indoors throughout the year (Israeli Dairy Reform, 1999–2008). The practice of keeping cows indoors for extended periods may also result from environmental regulations aimed at reducing leaching of nitrates and phosphorus into water reserves (for example, the "Nitrates Action Programme" implemented in Northern Ireland in 2007; Nitrates Action Programme and Phosphorus Regulations, 2015–2018).

Keeping animals indoors provides some important welfare benefits for the animals, such as protection from predators and toxic plants and reduced exposure to extreme weather conditions (Schütz et al., 2010) and external and internal parasites. In addition, this practice enables the provision of a nutritionally balanced diet throughout the year (Algers et al., 2009).

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However, it also confronts animals with a wide range of challenges. These include abiotic environmental sources of stress (e.g., exposure to loud and aversive sounds such as the noise produced by milking facilities, Arnold et al., 2007, 2008; metal-on-metal clanging, Waynert et al., 1999) and confinement-specific stressors that are more likely to be associated with indoor systems (e.g., restricted movement when kept tied in their stall, when isolated at an early stage of life, or maintenance in abnormal social groups, Morgan and Tromborg, 2007). Zero-grazing systems, compared with other production systems, are also associated with higher incidence of lameness (Haskell et al., 2006) and increased risk for claw or foot problems, teat trampling, mastitis, metritis, dystocia, ketosis, retained placenta, and some bacterial infections (Algers et al., 2009). Once housed, animals are forced to make substantial changes in their time budgets (Newberry, 1993). For example, the food searching and eating times of cattle may be reduced to 4 h/d, compared with 6 to 12 h on pasture (Gomez and Cook, 2010), such that long periods must be occupied with a limited range of possible behavioral patterns (Hughes and Duncan, 1988). Mason and Burn (2011) argued that when the environment is too impoverished (i.e., without appropriate stimuli or substrates) or too small, the ability of the animals to perform natural behaviors and to satisfy their motivations (i.e., to fulfill their behavioral needs) is restricted. Such behavioral restrictions may result in frustration. Indicators of frustration in cattle include leg stamping (Cooper et al., 2008, although this can also be associated with attempts to cope with forced standing by alleviating strain on the legs and hoofs), nonnutritive oral behavior (e.g., tongue rolling; Ishiwata et al., 2007), and an increase in the visible percentage of eye whites (Sandem et al., 2002), although the latter was also associated with fear (Sandem et al., 2004). Persistent frustration is associated with the development of abnormal behaviors. One example is calves' redirected oral behavior toward pen mates when fed from a bucket and restricted from performing suckling behavior (Mason and Burn, 2011; Ninomiya, 2014).

Keeping animals in an environment that meets their proximate needs ("here and now," Dawkins, 1983, such as feeding, drinking, and sleeping) allows them to engage in low-resilience behaviors (also referred to as "luxury activities"; that is, behaviors that typically decrease when energy resources are limited or when the cost involved in the activity increases; McFarland, 1999), which are associated with improved welfare and long-term fitness (Held and Spinka, 2011). One example is play behavior, which drops out of the animal's behavioral repertoire in times of challenge (e.g., sickness, hunger, injury, predation risk, and thermal stress). In the majority of cases, the presence of play behavior is associated with improved welfare, and its disappearance is a reliable indicator of the transition from positive to poor welfare (Held and Spinka, 2011). In cattle, other low-resilience behaviors include grooming (Borderas et al., 2008; Fogsgaard et al., 2012, but see also opposing findings by Almeida et al., 2008) and use of automated cow brushes (Mandel et al., 2013).

One strategy that can help animals cope with stressors in their surroundings, prevent frustration, and increase the fulfillment of behavioral needs is to enrich their environment. Newberry (1995) defined environmental enrichment as an improvement in the biological functioning of confined animals resulting from modifications to their environment. Biological functioning refers to increased fitness (i.e., lifetime reproductive success), increased inclusive fitness (i.e., indirect fitness, by helping genetically related individuals such as kin to increase their fitness), or a correlate of both, such as improved health. By focusing on the biological functioning of the animal, Newberry (1995) offered a practical and objective way to measure and evaluate the effect of different environmental enrichment methods on welfare. However, compromised welfare does not necessarily result only from impaired biological functioning (Fraser et al., 1997). For example, the welfare of bucket-fed calves is reduced not by malnutrition but by an unfulfilled need to suckle (Fraser et al., 1997). For the purposes of this review, effective environmental enrichment will therefore be regarded as a modification to the management or surroundings of the animal that demonstrably improves biological functioning (Newberry, 1995), or other validated measures of welfare (i.e., those measures that are correlated with valenced experiences; Nicol et al., 2009) over and above what is achieved by following minimum management standards (e.g., European Union guidelines).

Although environmental enrichment plays an important role in maintaining the wellbeing of zoo animals (Shyne, 2006), laboratory animals (Baumans and Van Loo, 2013), and certain livestock such as pigs (van de Weerd and Day, 2009; see also EU Directive 2008/120/EC, European Union, 2008a), its implementation on cattle farms is limited and has not coincided with the gradual shift toward year-round indoor housing and the challenges it places on cows. Considering the global increase in the number of cows and calves raised in zero-grazing systems, exploring different methods for meeting their needs (e.g., by enriching their environment) is more relevant today than ever before.

This review has 2 aims; first, we will review recent evidence of the effect of environmental enrichment on