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The effect of rearing substrate and space allowance on the behavior and physiology of dairy calves

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ABSTRACT

The objective of this study was to investigate the effect of rearing substrate and space allowance on the behavior and physiology of dairy calves. At 1 wk of age, 72 calves were moved into 1 of 18 experimental pens (n = 4 calves/pen) where they remained until 6 wk of age. Half of the pens had floors covered with quarry stones (QS) and the other half were covered with sawdust (SW). For each substrate type, calves were reared at 1 of 3 space allowances: 1.0, 1.5, or 2.0 m^2/calf. Behavior was video-recorded continuously for 24 h in the home pen at 2, 4, and 6 wk of age; the time calves spent lying, standing, walking, and running were estimated using 1-min instantaneous scan sampling. Body weight, cleanliness, fecal fluidity, and skin surface temperature were recorded at 1, 4, and 6 wk of age. *Escherichia coli* numbers were assessed on the skin surface of the shoulder and in feces of calves at 4 and 6 wk of age. Blood samples were taken at 1, 4, and 6 wk of age to measure cortisol, creatine kinase, immunoglobulin G, serum amyloid A, and total protein concentrations. Calves reared on QS spent less time lying and walking and more time standing at 4 and 6 wk of age compared with calves reared on SW. Furthermore, calves reared at a space allowance of 2.0 m^2/calf spent less time lying and more time standing and walking compared with calves reared at a space allowance of 1.0 and 1.5 m^2/calf. Calves reared on QS had lower skin surface temperatures compared with calves reared on SW. Fecal fluidity scores were lower in calves reared on QS than SW at 2 wk of age. Fewer *E. coli* were recovered from the shoulder of calves reared on QS than those of calves reared on SW, but fecal *E. coli* counts were similar between rearing substrates and space allowances. Serum amyloid A concentrations were lower in calves reared on QS than SW. We detected no effect of rearing substrate or space allowance on body weight, cleanliness, or concentrations of cortisol, creatine kinase, immunoglobulin G, and total protein. In conclusion, lower skin temperature in combination with reduced lying behavior may reflect reduced comfort of calves reared on QS. Furthermore, a space allowance of 2.0 m^2/calf may provide calves with more opportunity to perform active behaviors.

Key words: behavior, dairy calf, housing, welfare

INTRODUCTION

Housing and management practices during the preweaning period can affect the health and welfare of dairy calves. Important aspects of calf management and housing include rearing substrate and space allowance. Rearing substrates for calves evaluated in the literature include concrete, granite fines, rice hulls, rubber mats, sand, straw, stones, and wood shavings or sawdust (Panivivat et al., 2004; Hänninen et al., 2005; Hill et al., 2007, 2011; Camiloti et al., 2012; Sutherland et al., 2013). The type of substrate used in calf rearing facilities can affect calf cleanliness (Panivivat et al., 2004), weight gain and the incidence of diarrhea (Hill et al., 2011), skin surface temperature (Sutherland et al., 2013), and concentrations of acute phase proteins (Alsemgeest et al., 1995). Other factors associated with calf rearing substrates that could affect the health and welfare of calves include DM content, ammonia concentrations, substrate surface temperature, and bacteriology (Panivivat et al., 2004; Hill et al., 2011; Camiloti et al., 2012).

Substrate type used in rearing facilities can influence calf cleanliness, thermal comfort, and physiology. Panivivat et al. (2004) found that calves reared on granite fines had lower cleanliness scores than calves reared on sand, rice hulls, wheat straw, or wood shavings. Calves reared on river stones had lower skin surface temperatures than calves reared on sawdust, which may indicate reduced thermal comfort (Sutherland et al., 2013). In addition, Alsemgeest et al. (1995) found that serum amyloid A concentrations were affected by flooring type, with calves reared on a profiled durable plastic floor having higher concentrations than calves reared on a wooden floor with a rubber profile top layer.

Rearing substrate has been shown to influence behavior in dairy calves, with calves reared on rice hulls

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and sand spending more time self-grooming than calves reared on long wheat straw (Panivivat et al., 2004). Sutherland et al. (2013) found that calves reared on river stones spent less time performing locomotor play at 1 wk of age and 4.5% less time lying at 5 wk of age compared with calves reared on sawdust. Furthermore, dairy calves showed a clear preference for lying on dry sawdust and an aversion to lying on bare concrete (Camiloti et al., 2012).

Space allowance during the preweaning rearing period has been shown to influence BW and behavior of dairy calves. Body weight was higher in 35-d-old calves reared at a space allowance of 1.5 m^2/calf compared with calves reared at 2.25 and 4.0 m^2/calf (Tapkı et al., 2006). Tapkı et al. (2006) and Færevik et al. (2008) found no difference in lying times between calves reared at space allowances ranging from 0.75 to 4.0 m^2/calf; however, resting behavior was influenced by space allowance (Færevik et al., 2008). Tapkı et al. (2006) found that calves spent more time walking as space allowance increased. In addition, calves spent more time active (not lying down) and performing locomotor play as space allowance increased from 1.35 to 4.0 m^2/calf (Jensen et al., 1998).

In New Zealand (**NZ**), traditional rearing substrates, such as sawdust and wood shavings, are becoming difficult or expensive for farmers to obtain. Stones are an alternative rearing substrate used by some NZ dairy farmers because of cost, availability, and perceived improved calf health. However, there is limited scientific information available regarding the welfare implications of rearing calves on stones in relation to different management practices, such as space allowance. Therefore, the objective of this study was to investigate the effect of rearing calves on 2 substrate types (quarry stones and sawdust) at different stocking densities on calf behavior and physiology.

MATERIALS AND METHODS

Animals, Housing, and Feeding

This study was conducted between July and September 2012 at the AgResearch Dairy Research Farm, South Waikato (175°18 00′E, −38°03 00′S), NZ. All procedures involving animals were approved by the AgResearch Ruakura Animal Ethics Committee, under the NZ Animal Welfare Act (1999).

Seventy-two Friesian-cross dairy heifer calves were used in the study. The calves were separated from their dams within 24 h after birth and transported to the farm's calf rearing facility. Calves were kept in pens (15 calves per pen) with floors covered in woodchips before being moved to the experimental pens at approximately 6 d of age. Six adjoining experimental group pens were constructed in the middle of the facility. These pens were constructed from wooden panels that allowed auditory, visual, olfactory, and some tactile contact between animals in adjoining pens. Each large pen was then subdivided into 3 smaller pens that would provide a space allowance of 1.0, 1.5, or 2.0 m^2/calf. Pens were separated by wooden panels and a steel, paneled gate. All pens had plastic troughs for water (350 mm width × 300 mm length × 200 mm depth) and feed (310 mm width × 770 mm length × 260 mm depth) and these were attached to the side of the pen. All pens had dirt floors; in 3 of the large pens, the floor was covered with quarry stones (**QS**; Mangatangi River Rock Ltd., Auckland, NZ) with an approximate diameter of 40 to 60 mm, and the other 3 large pens were covered with sawdust (**SW**) with an average particle size of 10 mm. These are the estimates of stone size and particle size of the SW given by the suppliers. Rearing substrates were laid at a depth of approximately 30 cm. The stones and sawdust had not previously been used at the beginning of the study.

Calves were fed 2 L of colostrum twice a day at 0800 and 1630 h for the first 4 d after birth. Thereafter, an equivalent amount of milk replacement was offered (SupaCalf, Fonterra Ltd., Auckland, NZ) using a 5-teat milk feeder (Stallion Plastic Ltd., Palmerston North, NZ), which was removed after each feeding. Additionally, calves were given ad libitum access to a mixed feed of FiberStart (Fiber Fresh Feeds, Reporoa, NZ) consisting of 20% CP, 4% crude fat, and 25% crude fiber, and Topcalf Formula 20 (Inghams Feed & Nutrition, Hamilton, NZ) consisting of 20% CP, 5% crude fat, and 7% crude fiber. Water was provided ad libitum.

Experimental Design

At 6 d of age (±3 d), calves (38.4 ± 0.84 kg) were allocated to 1 of 6 treatment groups balanced for age and BW and then moved into the experimental pens containing QS or SW. For each substrate type, calves were reared at 1 of 3 space allowances: 1.0, 1.5, or 2.0 m^2/calf. The study was replicated 3 times and all treatments were represented during each replicate. For each replicate, 24 calves were tested simultaneously.

Environmental Conditions. The air temperature and ambient weather conditions in the barn were measured continuously during the trial period using weather stations (Vantage Pro2 Plus, Davis Instruments Corp., Hayward, CA) and portable Hobo Pro Data loggers (Onset Computer Corp., Bourne, MA). Four Hobo data loggers measuring rearing substrate surface temperature were located on each surface, in the middle of the barn and on the periphery. Two weather stations were

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