J. Dairy Sci. 100:1–9
https://doi.org/10.3168/jds.2016-12074

Health, physiology, and behavior of dairy calves reared on 4 different substrates

M. A. Sutherland,[1] G. M. Worth,[2] C. Cameron, C. M. Ross, and D. Rapp
AgResearch Ltd., Ruakura Research Centre, Hamilton 3214, New Zealand

ABSTRACT

The objective of this study was to compare the health, physiology, and behavior of group-housed calves reared on wood shavings with those reared on alternative surfaces. At 1 wk of age, 80 calves were moved into 1 of 20 experimental pens (n = 4 calves/pen) where they remained until 6 wk of age. Pens had floors covered with pea gravel (PG), rubber chip (RC), sand (SA), or wood shavings (WS; n = 5 pens/substrate). Body weight, cleanliness, health, and skin surface and vaginal temperature were recorded at 1, 3, and 6 wk of age. *Escherichia coli* numbers were assessed on the skin surface of the shoulder and in the feces of calves at 3 and 6 wk of age. Blood samples were taken at 1, 3, and 6 wk of age to measure hematological values and cortisol, IgG, and lactate concentrations. Behaviors (lying, running, and self-grooming) were recorded in the home pen at 1, 3, and 6 wk of age using video recorders and accelerometer data loggers. At 6 wk of age, calves were tested individually in an arena test and behavior was recorded continuously for 20 min. Body weight did not differ among calves reared on PG, RC, SA, or WS, regardless of age. All calves were clean and no calves displayed any signs of lameness, leg lesions, or injuries at wk 1, 3, or 6, regardless of substrate. The number of *E. coli* recovered from a surface area of 100 cm^2 on the shoulder of each calf was affected by rearing substrate, with more *E. coli* recovered from calves reared on WS than PG, RC, or SA at 3 and 6 wk of age. Fecal *E. coli* counts were not affected by rearing substrate at 3 or 6 wk of age. Over the entire study period, calves reared on PG and SA had lower skin temperatures than calves reared on RC or WS, but skin temperature was similar between calves reared on PG and SA. However, vaginal temperature did not differ among calves reared on different substrates at 1, 3, or 6 wk of age. Hematology values and cortisol, IgG, and lactate concentrations of calves were similar among rearing substrates over the 6-wk study period. In the home pen, rearing substrate did not influence time spent lying; however, calves reared on WS performed more lying bouts than calves reared on PG or SA. In addition, rearing substrate did not influence the time calves spent running; however, calves reared on WS spent more time self-grooming than calves reared on PG, RC, and SA. During a 20-min arena test, running, bucks, jumps, and kicks performed by calves was not affected by rearing substrate. In conclusion, the physiology and behavior of calves reared on PG, RC, and SA was similar to WS, which is considered the preferred rearing substrate to use when rearing calves. Therefore, PG, RC, and SA may be acceptable substrate options when rearing group-housed dairy calves.

Key words: behavior, dairy calf, housing, welfare

INTRODUCTION

The health and welfare of dairy calves during the first few weeks of life can be affected by housing and management practices. One important aspect of calf management is the rearing substrate used as this can affect calf growth, hygiene, health, and behavior. Several rearing substrates used in calf rearing systems have been evaluated in the literature including concrete, granite fines, rice hulls, rubber mats, sand (**SA**), straw, stones, and sawdust/wood shavings (Panivivat et al., 2004; Hänninen et al., 2005; Hill et al., 2011; Camiloti et al., 2012; Sutherland et al., 2013; Worth et al., 2015). Rearing substrate can affect calf cleanliness (Panivivat et al., 2004), weight gain and the incidence of diarrhea/scours (Panivivat et al., 2004; Hill et al., 2011), skin surface temperature (Sutherland et al., 2013), acute phase protein concentrations (Alsemgeest et al., 1995), and the level of bacterial contamination (Panivivat et al., 2004). However, studies investigating the effect of rearing substrate on calf health, physiology, and behavior have predominantly focused on individually housed or pair-housed calves.

Dairy calves are commonly housed individually during the first weeks of life to reduce risk of infectious

Received September 29, 2016.
Accepted November 21, 2016.
[1]Corresponding author: mhairi.sutherland@agresearch.co.nz
[2]Present address: LIC, Private Bag 3016, Hamilton 3240, New Zealand.

disease transmission among individuals. However, emerging evidence suggests that pair or group housing of calves has several benefits including reducing labor requirements and costs (Costa et al., 2015), increasing weight gains and intake of solid feed (Costa et al., 2015; Jensen et al., 2015), allowing calves to perform social behaviors important for development, and giving them more useable space (Jensen et al., 1998; Færevik et al., 2007; Costa et al., 2016). Due to this emerging change in calf management practices, it is necessary to evaluate the effect of different rearing surfaces on the health, physiology, and behavior of calves reared in group housing systems.

Organic materials, such as wood shavings (**WS**) and straw, are commonly used as rearing substrates for calves. Panivivat et al. (2004) found that calves reared on rice hulls, wheat straw, or WS had higher cleanliness scores than calves reared on granite fines or SA. Calves reared on WS also had higher skin surface temperatures than calves reared on stones, which may indicate increased thermal comfort (Sutherland et al., 2013). In addition, calves reared on rice hulls spent more time self-grooming than calves reared on long wheat straw or WS (Panivivat et al., 2004), and calves reared on WS spent more time lying and performing locomotor play in the home pen than calves reared on stones (Sutherland et al., 2013). Rearing substrate may also affect the motivation of animals to perform specific behaviors if those behaviors are restricted in the home pen; for example, calves reared on stones performed more play behavior than calves reared on WS when removed from the home pen and put into an arena test (Sutherland et al., 2014a). Dairy calves also show a clear preference for lying on dry WS and an aversion to lying on bare concrete (Camiloti et al., 2012) and prefer lying on WS than on SA (Worth et al., 2015). However, some organic substrates are becoming difficult or expensive for farmers to obtain, have higher moisture absorbent properties, and have higher bacteria contamination (Panivivat et al., 2004; Sutherland et al., 2014b). Therefore, rearing substrates that are easily accessible and that maintain good calf health and welfare need evaluating. Sand is commonly used as a lying surface for adult dairy cattle in free-stall systems, pea gravel (**PG**) has good drainage properties, and rubber chip (**RC**) has the advantage of being a recycled product with high insulation properties. Therefore, the objective of this study was to compare the health, physiology, and behavior of group-housed calves reared on WS with those reared on alternatives surfaces (SA, PG, and RC). It was predicted that the health, physiology, and behavior of group-housed calves reared on PG, RC, or SA would be similar to calves reared on WS.

MATERIALS AND METHODS

Animals, Housing, and Feeding

This study was conducted between July and September (Southern hemisphere winter) 2013 at the AgResearch dairy research farm, South Waikato (175° 18 00′ E longitude, −38° 03 00′ S latitude), New Zealand. All procedures involving animals were approved by the AgResearch Ruakura Animal Ethics Committee (#12961) under the New Zealand Animal Welfare act 1999.

Eighty Friesian-cross dairy heifer calves were used in the study over 5 replicates. The calves were separated from their dams within 24 h of birth and transported to the farm's calf rearing facility. The calf rearing facility had solid dirt floors and walls on all 4 sides. The walls were either solid or covered with shade cloth to reduce exposure from the wind. Calves were kept in group pens (15 calves per pen, 3 m × 7 m) with floors covered with wood chips before being moved to experimental pens at approximately 5 d of age. Experimental pens (2.5 m × 2.6 m) were located in the middle of the facility and were separated by wooden panel fences that allowed auditory, visual, olfactory, and some tactile contact between animals in adjoining pens. The floor of the experimental pens was covered in 1 of 4 substrates: (1) WS (*Pinus radiata* with an average particle size of 10 mm, (2) SA, (3) RC (with a particle size of 4 to 7 mm, Pacific Rubber, Auckland, New Zealand), and (4) PG (with an approximate diameter of 3–5 mm, Mangatangi River Rock Ltd., Auckland, New Zealand). Rearing substrates were laid over dirt floors at a depth of approximately 40 cm. Substrates had not been used before the start of the study. Wood shavings and SA pens were topped up with dry, clean substrate when pens became damp (approximately once a week), following the normal operating procedure at the farm. However, PG and RC were not cleaned during the experimental period as these pens remained relatively clean and dry throughout the experimental period.

Calves were individually fed 2 L of colostrum twice a day at 0800 and 1600 h for the first 4 d after birth. Thereafter, the equivalent amount of milk replacement was offered (Calf milk replacer, Milligans, Oamaru, New Zealand) using a 5-teat milk feeder (Calfateria series, MM5, Stallion Plastic Ltd., Palmerston North, New Zealand), which was removed after each feeding. Additionally, calves were given ad libitum access to TOPCALF Formula 20 (Inghams Feed & Nutrition, Hamilton, New Zealand) consisting of 20% CP, 5% crude fat, and 7% crude fiber, in plastic troughs (310 mm width × 770 mm length × 260 mm depth) at-