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Improved performance and heightened neutrophil responses during the neonatal and weaning periods among outdoor group-housed Holstein calves

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ABSTRACT

The objective was to determine if outdoor group housing of Holstein calves influences metabolic status, leukocyte responses, and behavior compared with individually housed calves. Forty-nine Holstein heifer calves (2 ± 1 d of age) were randomly assigned to 1 of 2 treatments: individually housed (G1; n = 22) or group housed [3 calves per pen (G3); n = 27]. The space allowances per calf were 4.8 and 7.0 m^2 for G1 and G3, respectively. All calves were offered an identical plane of milk replacer nutrition (747 and 1,010 g of DM/d of a 28% CP:20% fat milk replacer from wk 1 to 2 and wk 3 to 6, respectively). Weaning was initiated during wk 7 by removing the p.m. feeding and calves were completely weaned when they consumed 900 g of calf starter/d (as fed) for 2 consecutive days after d 54. At d 90, calves were commingled into random outdoor groups of 5 calves per pen. Peripheral blood was collected during the neonatal (d 3, 10, and 21), weaning (d 46, 48, and 54), and commingling periods (d 90, 93, and 98) and was analyzed for neutrophil oxidative burst (OB) capacity when cocultured with *Escherichia coli*, neutrophil surface L-selectin protein expression, and whole-blood secretion of tumor necrosis factor-α when cocultured with lipopolysaccharide. Starter intake was greater for G3 during the postweaning period (wk 8 to 12). Average daily gain was greater for G3 than G1 from d 54 to 68 and tended to be greater after commingling from d 113 to 133. During the neonatal period, G3 calves had more activated neutrophils, as evidenced by increased neutrophil L-selectin protein expression and a tendency for increased percentage of neutrophils producing an OB than G1 calves. During weaning, G3 calves continued to have more activated neutrophils with increased L-selectin expression on d 46 and 48 and a greater OB intensity throughout the period. No differences were observed among leukocyte responses between treatments at d 93 and 98. Outdoor group-housed Holstein calves had improved performance and heightened neutrophil responses compared with individually housed calves.
Key words: calf, housing, immune

INTRODUCTION

Passage of state and federal legislation has stressed the need to maintain gregariousness among animals early in life to preserve their natural behavior and potentially improve their welfare (Council of the European Union, 1997). Therefore, it is important to determine how and when dairy calves should be housed in groups. Animal grouping research is predominantly observational and performance based. A need exists for more data that determine the influence of calf housing on an animal's physiology and health before legislation determines how animals should be housed (Rushen, 1991).

Commingling of calves early in life was reported to increase calf starter intake (Warnick et al., 1977; De Paula Vieira et al., 2010), which could potentially result in healthier weaned animals. During commingling, animals are able to socialize and establish more natural responses to pen mates (Metz et al., 1986; Jensen et al., 1997; Chua et al., 2002). However, this system can create competition and more aggressive behavior within the pen (Andersen et al., 2004), leading to increased stress and dysfunctional behavior around humans (Györkös et al., 1999). This dysfunctional behavior is possibly caused by increased interaction and common associations with pen mates, resulting in excessive anxiety when approached by uncommon external stimuli. In addition, the transmission of microorganisms is increased by group housing (LeBlanc, 1981). Preweaned group-housed calves demonstrate cross-suckling and intersuckling that can result in the consumption of soil, hair, skin, and debris, leading to an increased risk for gastrointestinal upset (Broom, 1991; Redbo, 1992). Intersuckling, also termed milk stealing, when unsupervised and not discouraged, can lead to malnutrition in weaker calves and increased variability in the performance and health of calves in a herd (Lidfors and Isberg, 2003).

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The objectives of this experiment were to determine if outdoor-housed calves penned either individually or in small groups demonstrate differences in their performance, leukocyte responses, and behavioral characteristics during the neonatal, weaning, and commingling periods. It was hypothesized that group-housed calves would (1) consume more calf starter and have an increased ADG as a result of competition or learned behaviors, or both, (2) the physical and behavioral interactions among group-housed calves would increase leukocyte responses, and (3) group-housed calves would rely more on calf-to-calf than calf-human interactions.

MATERIALS AND METHODS

Experimental Design and Calves

All animal procedures were reviewed and approved by the Texas Tech University Animal Care and Use Committee. Forty-nine Holstein heifer calves (2 ± 1 d of age) were purchased and transported 78 km from a single commercial dairy farm and transported to the Hilmar Cheese and Agri-Plastics Calf Research Facility at Texas Tech University (New Deal, TX) in 4 enrollment groups over a 12-d period. All calves were fed 4 L of colostrum at the dairy within the first 12 h of life. Upon enrollment in the study, a peripheral blood sample was taken and individual total serum protein content was recorded using a hand-held refractometer (Atago USA Inc., Bellevue, WA). No differences were observed in total serum protein between groups and the sampled population average was 5.9 ± 0.50 g/dL (±SEM). Upon arrival at the research facility, calves were randomly assigned to either an outdoor individual hutch (**G1**; n = 22) or outdoor hutches in 9 groups of 3 calves per pen (**G3**; n = 27). Individually penned calves were housed in 2.13 × 1.09-m commercial polyethylene calf hutches attached to 1.83 × 1.09-m uncovered pens with no bedding, whereas group-penned calves were housed in 2.26 × 2.69-m commercial polyethylene hutches attached to 3.05 × 4.88-m uncovered pens with no bedding (Agri-Plastics Inc., Tonawanda, NY). A total of 4 calves died during the study; 2 calves from each treatment. Three of those calves died during the first 3 d of life and their data were omitted before statistical analyses. Calves displaying symptoms of respiratory disease were treated with florfenicol-flunixin meglumine (Resflor Gold; Merck Animal Health, Summit, NJ), with 3 and 1 calves for G1 and G3, respectively, being treated. The minimum and maximum temperatures during the experimental period were 19.6 and 34.3°C, respectively, and the average relative humidity, taken daily at 1000 h, was 44%.

Feeding, Weaning, and Measurements

All calves were offered 747 g of DM/d of a 28% protein and 20% fat milk replacer (**MR**; Cow's Match Holstein Blend; Land O'Lakes Animal Products Co., Shoreview, MN; Table 1) during the first 2 wk of life. The quantity of offered MR was increased to 1,010 g of DM/d during wk 3 to weaning. Milk replacer was mixed with warm water (43–48°C) to dissolve the powder and then mixed with cold water to reach the required volume at approximately 38°C and fed at 16.4% DM. The MR was offered to calves twice daily at 0800 and 1600 h for the duration of the study using plastic bottles with a nipple. Voluntary MR refusals were collected 15 min after each feeding. The research personnel limited intersuckling among group-housed calves by physically separating any calf that exhibited intersuckling. After the first week, all calves were offered ad libitum access to a pelleted calf starter (Table 1) and drinking water. Calf starter intake was recorded daily and adjusted for approximately a 10% refusal. No roughage was offered during the study. Weaning was orchestrated by block, with 2 enrollment groups in each weaning block. Weaning was started at d 46 by removing the 1600-h milk bottle. Calves were weaned completely when daily consumption of calf starter exceeded 900 g/d (as-fed basis) for 2 consecutive days after d 54.

On d 90, all calves were randomly commingled into larger groups (n = 5/pen) to simulate postweaning commingling growth performance. During this period (the grower phase), calves were fed 4.1 kg of concentrate pellets DM (AMPLI-Calf; Purina Mills LLC,

Table 1. The formulated nutrient content of the milk replacer and calf starter on a DM basis

Nutrient	Milk replacer	Calf starter[1]
CP, %	28.0	20.0
Ether extract, %	20.0	2.2
Crude fiber, %	0.15	16.0
ADF, %	—	18.0
Calcium, %	1.0	1.0
Phosphorus, %	0.70	0.50
Selenium, mg/kg	—	0.30
Vitamin A, IU/kg	44,000	7,700
Vitamin D_3, IU/kg	11,000	—
Vitamin E, IU/kg	220	—

[1]The calf starter (Cornerstone AMPLI-Calf) with monensin was fed using macro-ingredients, which included grain products, processed grain by-products, plant protein products, molasses, and roughage products (Purina Mills LLC, Gray Summit, MO). Also, the calf starter was formulated with a proprietary blend of a yeast extract, fructooligosaccharide, anise oil, garlic oil, cassia, ethyl vanillin, and propylene glycol. The trace mineral and vitamins used in the calf starter were mostly organic sources, including zinc amino acid complex, manganese amino acid complex, copper amino acid complex, cobalt glucoheptonate, and cobalt proteinate.