Complex social housing reduces food neophobia in dairy calves

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ABSTRACT

Animals are often reluctant to consume novel feeds. Research suggests that social housing can reduce fearfulness in animals. The aim of this study was to test the prediction that social housing reduces food neophobia in dairy calves. Beginning immediately at birth, Holstein bull calves were either reared individually ($n = 18$) or in a complex social group with other calves and cows ($n = 18$). In food neophobia tests, calves were exposed to 2 identical buckets, one empty and the other filled with a novel food (chopped hay in trial 1 and chopped carrots in trial 2). Calves were tested for 30 min/d on 3 consecutive days starting at 70 d of age. Regardless of the type of food, socially housed calves consumed more of the novel feed compared with individually housed calves. In trial 1, intake of hay as fed averaged 35 ± 6 versus 18 ± 6 g/d for socially versus individually housed calves. In trial 2, intake of chopped carrots as fed averaged 27 ± 6 versus 6 ± 6 g/d for socially versus individually housed calves, respectively. Social rearing decreased the latency to eat the novel feed. Calves housed in a complex social group began eating the hay after $1:23 \pm 1:13$ versus $3:58 \pm 1:10$ min:s for individually housed calves. Latency to begin eating the chopped carrots averaged $3:09 \pm 1:17$ versus $6:38 \pm 1:13$ min:s for socially versus individually housed calves. Treatment had no effect on time spent eating, latency to approach the food bucket or the empty bucket in either trial, or on time spent manipulating the empty bucket. These results indicate that housing dairy calves in a complex social group reduces food neophobia. More generally, this study contributes to a series of studies showing that calves raised in more complex social environments may be better able to transition to other changes in their environment.

Key words: feeding behavior, group housing, weaning, dietary transition

INTRODUCTION

Dairy cattle are often exposed to new foods. For example, calves are weaned from milk to a grain-based

calf starter and later to forage-based diets (see review by Khan et al., 2011). Food neophobia is well known in ruminants (Chapple and Lynch, 1986) and is defined as avoidance of, and reluctance to taste, unfamiliar foods (Cooke et al., 2006). Food neophobia is adaptive in that it helps animals avoid toxic foods and those too rich in certain nutrients (Provenza, 1995), but food neophobia can be problematic when animals refuse novel feeds provided as part of the farm's management requirements (Villalba et al., 2010). Ruminants offered novel diets often sample these cautiously, resulting in decreased food intake and productivity (Launchbaugh et al., 1997).

Surveys on dairy practices in Canada (Vasseur et al., 2010) and the United States (USDA, 2008) indicate that more than 90% of farms routinely separate calves from their dams within 24 h of birth and then typically house calves in individual pens or hutches. In more naturalistic settings, the dam and calf will typically remain in close contact until approximately 6 to 8 mo and commingle with other calves and cows (Reinhardt and Reinhardt, 1981).

Early socialization during the milk-feeding phase, generally the first 6 to 8 wk of life for dairy calves, appears to reduce the problems associated with the transition to new social and feeding environments (de Paula Vieira et al., 2012b). Social contact with the dam and other calves has been shown to decrease responses to restraint and increase play (Duve et al., 2012). Also, calves that are pair housed early in life begin to ingest solid feed sooner and eat more solid feed during the milk-feeding phase compared with calves housed individually (de Paula Vieira et al., 2010). Calves housed individually show less exploratory behavior (Jensen et al., 1997; de Paula Vieira et al., 2012a) and are more reactive to environmental and social novelty compared with socially housed calves (de Paula Vieira et al., 2012b). Collectively, these results suggest that providing access to more complex social environments may improve the calf's ability to cope with novel feeds. We therefore hypothesized that providing a complex social environment for calves would improve calves' willingness to consume new food items.

An important aspect of modern dairy cow management is the ability to change diets to meet the changing needs of the animal and to match availability of

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feedstuffs, making it important that the animal be able to transition to new types of feed. Thus, the aim of this study was to investigate the effect of complex social housing on neophobic responses to new food items.

MATERIALS AND METHODS

This experiment was carried out between October 2012 and May 2013 at The University of British Columbia's Dairy Education and Research Centre (Agassiz, British Columbia, Canada; 49°N, 121°W). All procedures were approved by the University of British Columbia Animal Care Committee.

Animals and Housing

Thirty-six Holstein dairy bull calves were assigned either to individual ($n = 18$) or to complex social ($n = 18$) housing. Individually raised calves were separated from their dams immediately after birth and moved to sawdust-bedded pens (1.2 m $\times$ 2.0 m) with auditory but no visual contact with other calves (Figure 1a). Socially housed calves were kept with their dam in the calving pen for 3 d after parturition. Immediately after parturition, cows were fitted with udder nets (Large Mesh Udder Support, Franksville Specialty Company, Phillips, WI) to prevent calves from accessing the teats. Cow and calf were moved to a dynamic group of cows and calves housed in a single pen containing 12 freestalls (Figure 1b). The dynamic group varied in size from 4 to 8 cow-calf pairs over the course of the study; calves were removed from the group at 75 d and calves entered the group at all times up to the maximum of 8 calves per pen. Calves were granted access to the cows' pen at night (1900 to 0700 h). During the day, calves were restricted to a sawdust-bedded calf creep located immediately adjacent to the cow' pen and connected by 2 doors located at either end of the pen. A fence-line system allowed cows and calves to physically interact (e.g., nose touch) during the day. Pens and the calf creep were cleaned and new sawdust replaced once per week. Calves were weighed and received weekly health checks following the standard operating procedures of the farm, and the herd veterinarian treated any calves identified as ill. Four calves from the social group and 3 calves from the individual group were treated for diarrhea, and 1 calf from the social treatment was treated for respiratory disease during the experimental period.

Calves in both treatments were fed 4 L of colostrum by bottle within 6 h of birth. From d 0 to 28 of age, all calves received 8 L/d of whole pasteurized milk, divided in 2 feedings, delivered by bottle at 0700 and 1630 h. From d 29 to 49, calves were fed 6 L/d, also

divided into 2 feedings as described above. From d 50 to 54, milk was reduced by 20%/d such that calves were completely weaned at d 55. Calves remained in the same pen until d 75. All calves had ad libitum access to water, TMR (49% DM; consisting of 26% corn silage, 15% grass silage, 10% alfalfa hay, and 49% concentrated mix), and calf starter (90% DM; CP 21%, NDF 19%, ADF 11%; Hi-Pro Medicated Calf Starter, Chilliwack, BC, Canada). Fresh feed and water were delivered daily at approximately 0830 and 1700 h, and feed refusals were removed and weighed just before fresh feed was delivered. Eight calves were continuously observed by video from 0800 h on the day before neophobia testing until 0800 on the test day, and the time spent eating TMR and calf starter were recorded. Eating was defined as when the calf's muzzle was inside the feed bucket.

Procedures

Neophobia tests were chosen to assess the calves' behavioral responses toward a novel food. The test was repeated for 3 consecutive days to assess habituation to the new food. Testing started when calves were 70 d of age (2 wk after weaning) and tests were performed starting at 1500 h.

The test arena, measuring 1.2 m $\times$ 2 m with 1.2-m walls, was located adjacent to the pens where the calves were housed and was bedded with 5 cm of fresh sawdust. Calves received all their milk meals in the test arena from 4 d of age until weaning at 56 d, so calves were fully habituated to the enclosure at the time of testing. Calves were not able to see other calves while in the test arena.

Two white 20-L plastic buckets, identical to those used to provide water in the home pens, were placed in each corner of the wall opposite the door of the arena. One bucket contained 2 kg of the novel food; the other bucket remained empty.

A subset of (20 of the 36) test calves was tested with orchard grass hay (83% DM; CP 17%, NDF 49%, ADF 28%) as the novel feed (trial 1; $n = 10$ per treatment). A second subset (the remaining 16 test calves) was tested with chopped carrots as the novel feed (trial 2; carrots were manually chopped into approximately 3-g pieces on the morning of the test day; $n = 8$ per treatment). The position of the bucket containing the novel food was varied at random between the 2 corners for each test. Calves were placed into the test arena for 30 min. At the end of the test, feed refusals were weighed and total intake (on an as-fed basis) was determined.

Behavior was video recorded continuously during the neophobia tests (DCRSR100 HDD Handycam Camcorders; Sony Corp., Park Ridge, NJ) using video

Figure 1. Experimental pens for (a) calves reared individually, and (b) for calves reared in a complex social group with their dam and other calves and cows. Individual pens were 2.4 m² (1.2 m × 2.0 m) with sawdust bedding and auditory but no visual contact allowed with other calves. Socially housed calves were kept with a group of cows and calves housed in a single pen containing 12 freestalls; calves were granted access to the freestall pen at night (1900 to 0700 h) and were restricted during the day to a sawdust-bedded calf creep (3.5 m × 12.3 m) located immediately adjacent to the freestall pen.

cameras positioned directly above the test pen. Video recordings were used to measure latency to approach the feed (muzzle <5 cm from the bucket), latency to approach the empty bucket (muzzle <5 cm from the bucket), latency to eat (collection or chewing of the feed), time spent eating (head in the bucket), and time spent manipulating the empty bucket (licking, sniffing, or head in the bucket).

Statistical Analyses

All analyses were performed with SAS (version 9.3; SAS Institute Inc., Cary, NC) using the calf as the experimental unit. Intake of the novel feed (g), latency to approach the feed and empty buckets, latency to eat, time spent eating (head in the bucket), time spent with muzzle within 15 cm of the bucket, time spent

eating the day before the neophobia test in the home pen (all measured in s), and BW (kg) were considered as dependent variables. Data were scrutinized using the UNIVARIATE procedure and probability distribution plots in SAS. Where necessary, a square-root transformation was used to normalize error distributions; back-transformed results are presented for these data. Results throughout the text are present as least squares means and standard errors of the mean, F -values (df_{effects} , df_{error}), and P -values.

The effect of the housing treatment on each variable was analyzed with a linear mixed model, using the MIXED procedure in SAS (SAS Institute Inc.). The model included the effects of trial (1 versus 2), experimental day (specified as a repeated measure), and calf (specified as subject), and used an autoregressive covariance structure. The variables time spent eating the day before the neophobia test and BW (kg) were analyzed in a different model that included the effects of trial (1 versus 2) and birth weight. Significance was declared at $P < 0.05$.

RESULTS

Calves housed in the complex social environment consumed more of the novel food than did individually housed calves in trials 1 and 2 (Figure 2a; $F_{1,33} = 18.44$, $P < 0.01$). Calves tended to eat more during trial 1 (hay) than during trial 2 (chopped carrots) ($F_{1,33} = 3.53$, $P = 0.07$), but we detected no interaction between treatment and trial ($F_{1,33} = 2.15$, $P > 0.1$). The amount of novel feed consumed did not change across the 3 test days (Table 1; $F_{2,69} = 0.22$, $P > 0.1$) and there was no day $\times$ treatment interaction ($F_{2,69} = 0.71$, $P > 0.1$).

Social rearing decreased the latency to eat novel feed in both trials (Figure 2b; $F_{1,35} = 12.86$, $P < 0.01$). Latency to approach was shorter for hay than for carrots ($F_{1,35} = 6.90$, $P = 0.01$), but we detected no interaction between treatment and trial ($F_{1,35} = 0.01$, $P > 0.1$). Latency to eat the novel feeds did not change across testing periods ($F_{2,57} = 0.27$, $P > 0.1$) and no interaction was found between test day and treatment (Table 1; $F_{2,57} = 0.29$, $P > 0.1$).

Treatment did not affect the time calves spent eating the novel feeds; calves spent, on average ($\pm$ SD), 4:06 $\pm$ 4:03 min:s eating hay and 2:59 $\pm$ 4:09 min:s eating carrots. Also, treatment did not affect latency to approach the food bucket or the empty bucket, and we observed no effect of treatment on time spent manipulating the empty bucket (Table 2). Body weight at the time of testing averaged $\pm$ SD 93.0 $\pm$ 11.83 kg and did not differ between treatments ($F_{1,36} = 2.54$, $P > 0.1$). The time calves spent eating solid feed in the home pen on the day before the neophobia tests averaged $\pm$ SD

3:19:35 $\pm$ 1:08:42 (h:min:s) and again did not differ between treatments ($F_{1,14} = 0.83$, $P > 0.1$).

DISCUSSION

These results show that rearing in a complex social environment reduces food neophobia in dairy calves. Calves kept in a more complex social environment approached novel feed items more rapidly, spent more time in close contact with these items, and consumed

Figure 2. Least squares means ($\pm$ SE) of (a) intake of novel feed (g/test; as-fed), and (b) latency to eat novel feed (min:s/test). Calves were assigned to housing either in a complex social group with the dam and other cows and calves or individual rearing. In trial 1 ($n = 10$ per housing treatment), calves were tested with exposure to novel hay; in trial 2 ($n = 8$ per treatment), calves were tested with chopped carrots. Tests were 30 min/d for 3 d. Analyses were based upon square root-transformed data; back-transformed data are presented.

Table 1. Least squares means ($\pm$ SE) intake of novel feed (g/test) and latency to eat (min:s) during 3 consecutive days of testing¹

Variable/day	Trial 1: Hay		Trial 2: Carrots	
	Individual	Social	Individual	Social
Intake (g/test)				
1	17 $\pm$ 8	34 $\pm$ 8	6 $\pm$ 9	27 $\pm$ 9
2	14 $\pm$ 8	47 $\pm$ 8	8 $\pm$ 9	26 $\pm$ 9
3	23 $\pm$ 8	24 $\pm$ 8	5 $\pm$ 9	29 $\pm$ 9
Latency to eat (min:s)				
1	2:47 $\pm$ 0:07	1:24 $\pm$ 0:06	7:02 $\pm$ 0:08	2:40 $\pm$ 0:07
2	4:48 $\pm$ 0:07	1:16 $\pm$ 0:06	6:37 $\pm$ 0:07	2:51 $\pm$ 0:06
3	4:20 $\pm$ 0:07	1:31 $\pm$ 0:07	6:26 $\pm$ 0:07	3:50 $\pm$ 0:06

¹Calves were assigned to housing either in a complex social group with the dam and other cows and calves or individual rearing. In trial 1 ($n = 10$ per housing treatment), calves were tested with exposure to a novel hay; in trial 2 ($n = 8$ per treatment), calves were tested with chopped carrots. Tests were 30 min/d for 3 d. Analyses were based upon square root-transformed data; back-transformed data are presented.

a greater quantity of feed compared with calves kept in the conventional individual calf pens. These findings held true for 2 different types of novel feed tested in the current study. To our knowledge, this study is the first to demonstrate that early social experience reduces food neophobia in calves or indeed in any species. Our results are consistent with earlier research in piglets showing that environmental enrichment before weaning (i.e., increased space allowance and provision of straw, wood shavings, peat, and branches) increased the acceptance of piglets of a new diet and increased exploratory behavior after weaning (Oostindjer et al., 2011a,b).

Previous work has shown that calves tested at 90 d of age were more reactive to environmental and social novelty if they had been housed individually for the first 3 mo of life compared with calves that had been pair-housed over the same period (Jensen et al., 1997). A recent study has also shown that individual housing can impair cognitive performance and behavioral flexibility in dairy calves (Gaillard et al., 2014), and these differences may be due in part to differences in reactivity.

de Paula Vieira et al. (2010) found that pair-housed calves consumed more solid feed before weaning compared with calves that had previously been individually housed. This beneficial effect of social rearing on intake of solid feed in the home pen may have been due to social facilitation (i.e., the presence of other animals facilitating the expression of a behavioral response; Weiss and Miller, 1971). However, in the current study, we tested calves individually in a test pen, so calves had no opportunity to observe and imitate the behavior of other calves exposed to the novel feed. We conclude that the treatment differences in the current study were not due to social facilitation.

Calves that eat more solid feed in the home pen may gain more BW and, because these animals will be both larger and more familiar with solids, we may expect these animals to also consume more of the novel feed in the test session. We were unable to quantify individual intake of (familiar) solid feed in the home pen for the complex socially housed calves, thus we could not compare intakes of calves in the 2 treatments. However, treatments did not differ in BW or in the time calves spent eating solid feed on the day before the test.

Table 2. Least squares means ($\pm$ SE) latency (min:s/test) to approach the feed, latency (min:s/test) to approach the empty bucket, time (min:s/test) spent eating, and time (min:s/test) spent manipulating empty bucket¹

Time (min:s)	Trial 1: Hay		Trial 2: Carrots		<i>P</i> -value ²		
	Individual	Social	Individual	Social	Treat	Trial	Treat $\times$ Trial
To approach the feed	1:39 $\pm$ 0:02	0:47 $\pm$ 0:02	1:40 $\pm$ 0:02	1:53 $\pm$ 0:02	0.35	0.15	0.17
To approach empty bucket	2:55 $\pm$ 0:41	3:02 $\pm$ 0:39	2:05 $\pm$ 0:42	2:52 $\pm$ 0:40	0.50	0.47	0.62
Eating	2:10 $\pm$ 0:08	4:48 $\pm$ 0:08	1:10 $\pm$ 0:08	2:10 $\pm$ 0:07	0.14	0.13	0.65
Manipulating empty bucket	2:45 $\pm$ 1:11	2:41 $\pm$ 1:11	5:58 $\pm$ 1:10	5:54 $\pm$ 1:07	0.95	0.01	0.99

¹Responses were measured for 30 min on 1 d only. Calves were assigned to housing either in a complex social group with the dam and other cows and calves or individual rearing. In trial 1 ($n = 10$ per housing treatment), calves were tested with exposure to hay; in trial 2 ($n = 8$ per treatment) calves were tested with chopped carrots. Analyses were based upon square root-transformed data; back-transformed data are presented.

²*P*-values are shown for treatment (Treat), trial (Trial), and the interaction between treatment and trial (Treat $\times$ Trial).

These results suggest that the treatment differences in response to the novel feeds cannot be explained simply on the basis of motivation to consume, or familiarity with, solid feed.

An alternative explanation is that socially reared calves were more motivated to express exploratory behavior; exploratory behaviors provide animals with information about their environment and are likely to be more valuable in complex and variable environments. Jensen et al. (1997) found that calves reared without social partners during the first 3 mo of life showed delayed exploratory behavior compared with pair-raised calves. Similarly, de Paula Vieira et al. (2012a) found higher levels of exploratory behavior in calves reared socially compared with individually reared calves. However, in the current study, calves in the 2 treatments did not differ in latency to approach the feed or empty buckets, only in time to eat the novel food and the amount consumed during the test. Thus, the current results suggest that the treatment effects may be more specific to the avoidance of, and reluctance to taste, unfamiliar foods.

Over the 3 d of testing, we found no differences in intake or in latency to eat or approach the feed, suggesting that the neophobic response persists for at least this period. We had expected that the neophobic response would decline on d 2 and 3 of testing; future work should test animals over a longer period to determine if and when intakes in the 2 treatments converge.

All the tests were performed while calves were kept individually in the test pen. The calves were habituated to this procedure and to the test pen as they had received all their milk meals in this way from d 3 of age. However, it is possible that the brief period of social isolation in the test pen would be more of a stressor for the socially reared calves than for calves that were housed individually at all times. If this were the case, we would expect that calves housed in the complex social environment would be more fearful (and thus less willing to approach the novel food) when tested in isolation, but our results showed the opposite pattern. We conclude that the short period of isolation in the test pen did not cause increased fearfulness in the socially reared calves.

Delayed acceptance of new food items may be a welfare and production concern. Dairy cattle are often exposed to new feed types, including when first transitioned from milk to solid feed at weaning. In addition to changes in diet, dairy cattle may be exposed to a range of management practices that introduce novelty to the environment, such as changes in pen location, regrouping with new social partners, and new milking procedures. Each of these changes may be more problematic for both the animal and the farmer if cattle are

fearful of novel conditions. The current study found that complex social housing reduced responses to novelty when calves were still young; it is not known if this effect persists as the calf ages. Future experiments should investigate the longer-term effects of different dairy calf housing systems on behavioral flexibility and whether the effects found in this study can be generalized to other challenging situations in the lives of calves.

CONCLUSIONS

A complex social housing environment, where calves had access to their dam and other cows and calves, increased intake and decreased latency to approach and eat 2 different types of novel feeds. Delayed acceptance of new food items can be a welfare and production concern, as dairy cattle are often exposed to new feed types. Individual rearing may reduce the calf's ability to adapt to changes in feed and perhaps other changes in their environment.

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