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Behavioural changes at weaning in 6-month-old beef calves reared by cows of high or low milk yield

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Abstract. The objective of this experiment was to determine the differences in behavioural changes observed in 6-month-old beef calves at weaning in relation to milk yield availability from their dams. Eighteen Hereford or Hereford × Angus crossbred primiparous cows from a single herd remained with their calves suckling until the beginning of the experiment (194.1 ± 1.9 days after calving). On day 0, calves were moved to a 100-m^2 corral far from their mothers, which were taken to a field more than 1000 m away, and returned to the original paddock on day 1. Milk production was determined monthly during the lactation period in 14 of the 18 cows. Calves' behaviour was recorded using instantaneous sampling of individual animals in each group every 10 min from 0800 to 0950, 1200 to 1350, and 1600 to 1750 hours. Recordings were performed from day –3 to day 5, except on day 0. The calves from the five cows with higher milk yield (HMY) and the calves from the five cows with lower milk yield (LMY) were considered for data analysis. Milk yield was greater in HMY than LMY cows throughout all the lactation. HMY calves tended to suckle more frequently than LMY calves. There were no differences in average daily gain after weaning between HMY and LMY calves. However, HMY calves were heavier at weaning than LMY calves. The frequency of grazing, ruminating, walking and standing differed between HMY and LMY calves, and was affected by weaning. For example, calves from HMY cows spent less time grazing before and after weaning than calves from LMY cows. There were also interactions between group and time on the frequency of these behaviours. Overall, we conclude that the behaviour of 6-month-old beef calves at weaning differed according to their mothers' milk yield, and their developmental growth stage.

Introduction

Weaning of beef cattle is generally performed by abruptly separating the young from the mother. This means the calf has to adapt simultaneously to the loss of milk and to the separation from the dam. Physiological (Lefcourt and Elsasser 1995; Hickey *et al*. 2003) and behavioural (Veissier and Le Neindre 1989; Price *et al*. 2003; Haley *et al*. 2005) changes have usually been used as indicators of stress provoked by weaning (Newberry and Swanson 2008; Weary *et al*. 2008). However, the studies that focussed on the behavioural changes of beef calves at weaning did not attempt to disentangle the effects of breaking the mother–young bond from those provoked by the end of suckling and diet substitution.

According to our knowledge, there are no studies relating cows' milk yield and calf response to weaning. In swine, Mason *et al*. (2003) showed that piglets that presumably consumed more milk, called more and had higher cortisol levels at weaning than piglets that had access to teats with lower milk yields. It may be expected that if the loss of milk supply is involved in the distress response at weaning, different milk availabilities may determine different calves' behavioural responses at weaning. In that sense, it has been reported that continued access to a milk-feeding apparatus of dairy calves for 2 days after weaning reduced their distress response (Budzynska and Weary 2008). Therefore, the abrupt end of suckling behaviour may also be involved on the distress response of calves to weaning.

It should also be considered that the amount of milk available from cows might qualitatively influence the dam-calf bond. Although it has not been clearly established in cattle, the oxytocin surge provoked during parturition determines the onset of the maternal motivation in sheep (Poindron 2005). As oxytocin is released during suckling (Lupoli *et al*. 2001) it may be interesting to speculate that the cow-calf bond is influenced by suckling and, therefore, by the cows' milk supply. However, according to our knowledge, there are no studies relating the milk yield of the dam with the establishment or maintenance of the social relationship with their calves.

We predicted that calf behavioural patterns suggesting distress should differ at weaning according to their mother's milk yield. Therefore, the objective of this experiment was to determine the differences in behavioural changes observed in 6-month-old beef calves at weaning in relation to milk yield availability from their dams.

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Materials and methods

Animals and management

The experiment was performed in the Experimental Farm Palo a Pique, Instituto Nacional de Investigación Agropecuaria Treinta y Tres (34°S), Uruguay, in September (from late winter to early spring). From April to September there was a serious drought affecting the region. Eighteen Hereford or Hereford × Angus (35- to 37-month-old) primiparous crossbred cows, all coming from a single herd, remained with their calves suckling until the beginning of the experiment (194.1 ± 1.9 days after calving; range 181–204 days). Calf bodyweight at birth (2–4 days after birth) was 32.2 ± 0.9 kg without differences between experimental groups.

During the experiment cows and calves remained as a single group, grazing native pastures. On day 0, calves were moved to a 100-m^2 corral far from their mothers, which were taken to a field more than 1000 m away. The calves returned to the original paddock on day 1. Calves were weighed on days –24, –11, 0, 7, and 21.

Milk production composition and quality

From April to August, cows were involved in another experiment with different nutritional availabilities (G. Quintans, G. Banchero, C. Lòpez, M. Carriquiry, F. Baldi, unpubl. data). Milk production was determined monthly from April to September in 14 of the 18 cows that were used in the experiment. In each sampling, at 1700 hours cows were separated from calves and each cow was injected intramuscularly with 10 IU of oxytocin (Hipofamina, Laboratorio Dispert SA, Montevideo, Uruguay). Two minutes after the injection cows were milked using a portable milking machine. After milk flow had ceased, the machine was removed. To minimise stress of the dam managed under range conditions, suckling was prevented with nose-flap anti-suckling devices, and calves remained with their dams in the same paddock. The following day, at 0600 hours, cows were milked again with the same protocol, and the milk obtained was weighed and a sample taken for analysis of composition and quality. Nose-flaps were removed after milking and cows and calves returned to the paddock. Milk samples were kept fresh and delivered to the Dairy Laboratory at INIA La Estanzuela, where fat, protein, and

Table 1. List of behaviours observed and respective descriptions

Behaviour	Definition
Standing	Maintaining an upright position on extended legs
Lying	Lying down in any resting position
Walking	All four legs are moved with head raised
Grazing	Picking or consuming pasture, with the head above ground, still or moving slowly
Ruminating	Chewing regurgitated boluses of feed
Drinking	Mouth on water trough ingesting water
Suckling	Acquiring milk by sucking cow's teats and deglutition signals
Playing	Making activities experienced as pleasurable (running, jumping, handling objects without any apparent function, etc.)
Pacing	Moving parallel to, within 1 m of, the fence
Seeking	Beside the fence head straight with eyes and ears focussed in the same direction (outside the paddock)
Vocalisations	Making sounds through the mouth

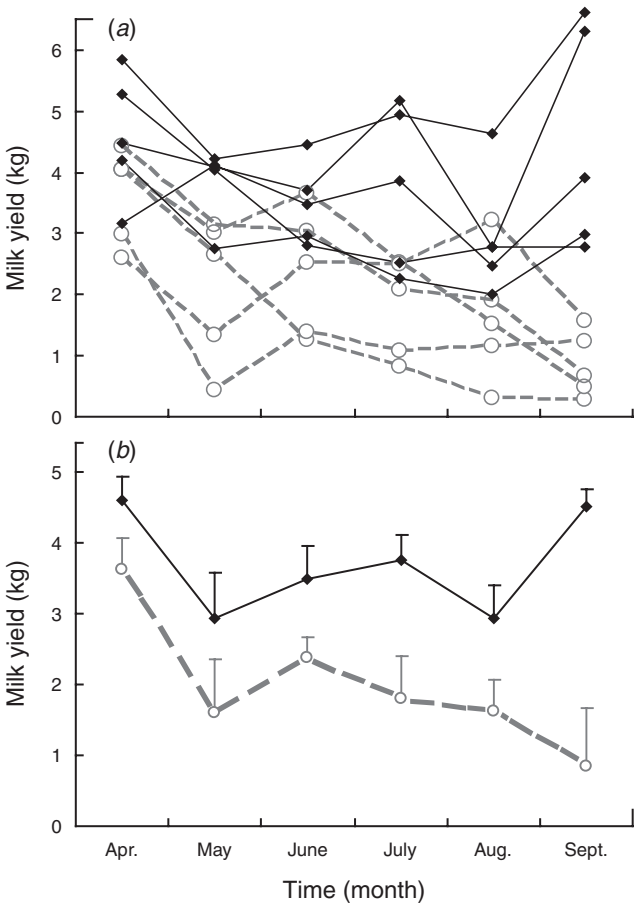

Fig. 1. Milk production during the 6 months before the onset of the experiment: (*a*) individual data, and (*b*) mean values in cows with high (♦) or low (○) milk yield.

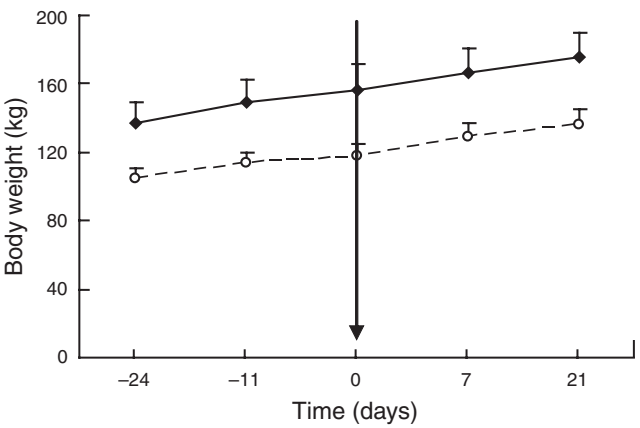

Fig. 2. Bodyweight in calves from mothers with high (♦) or low (○) milk yield. The arrow indicates weaning, which was when calves were ~6 months old.

lactose percentages were determined using a Bentley 2001 (Bentley Instruments, Chaska, MN, USA).

Behavioural recordings

Behaviours were recorded using direct visual instantaneous sampling of individual calves in each group every 10 min. Data were recorded 36 times/day, from 0800 to 0950, 1200 to 1350, and 1600 to 1750 hours. Recordings were performed from day –3 to day 5, except on day 0. In each sampling, the different behaviours listed in Table 1 that were performed by the calf were recorded. For a 15-s period every 10 min, the occurrence of vocalisations was noted using 0/1 sampling (Lehner 1996).

Data analysis

The calves from the five cows with the highest milk yield (HMY) and the five cows with the lowest milk yield (LMY) were considered for data analysis. Milk yield was compared with an ANOVA for repeated measurements, and milk composition in the last milk yield determination, and the difference on milk yield between the last and the previous determination were compared with ANOVA. Frequencies for

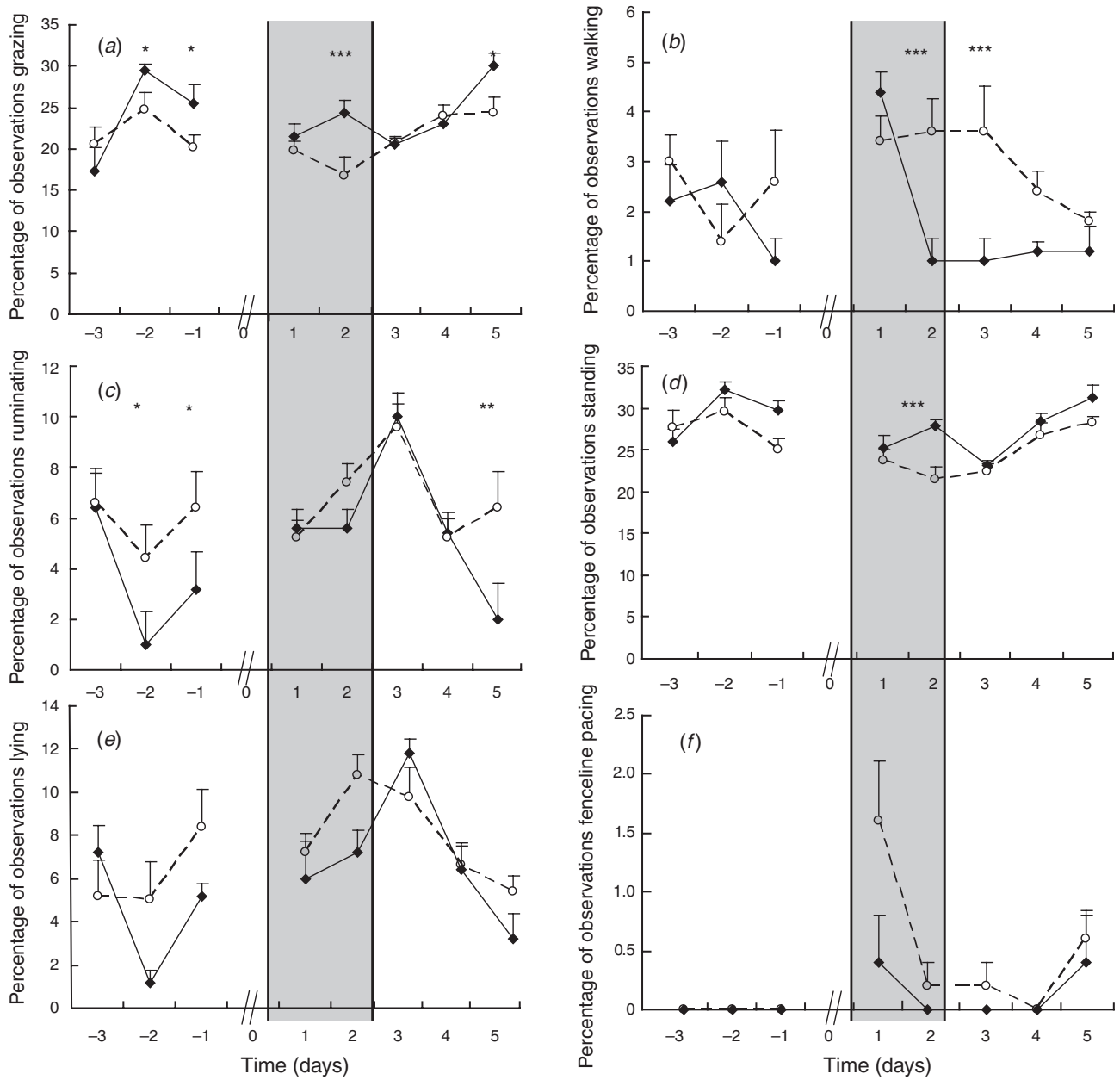

Fig. 3. Frequency of the behaviours that were affected by treatment [high (♦) or low (○) milk yield dams]: (*a*) grazing; (*b*) walking; (*c*) ruminating; (*d*) standing, or tended to be affected by treatment; (*e*) lying. (*f*) There was an effect of time, and a tendency for a treatment × time interaction for fenceline pacing frequency. The grey area indicates the first 2 days after weaning.

each behavioural event are expressed as percentages, and presented as mean ± s.e. Frequency of each behaviour, bodyweights, and average daily gain (ADG) were compared with a mixed model for repeated measurements considering the group (HMY or LMY), and the time, as well as the interaction between treatment and time as fixed effects, and the calf into each group as a random effect. Post-hoc comparisons were done with least significant difference. Differences were considered significant at $\alpha = 0.05$.

Results

Milk composition and suckling

Milk yield was influenced by month (postpartum time; $P < 0.001$) and was greater in the HMY than the LMY group ($P = 0.01$). Individual milk yield profiles are presented in Fig. 1*a*, and mean values for HMY and LMY cows are presented in Fig. 1*b*. In August (last measure), milk yield ranged from 0.3 to 1.6 kg, and from 2.8 to 6.6 kg in LMY and HMY cows, respectively. While milk yield increased 1.6 ± 0.6 kg from August to September in HMY cows, in LMY cows it decreased 0.8 ± 0.6 kg ($P = 0.004$). Percentage of fat (HMY and LMY: 2.9 ± 0.3% *v.* 2.1 ± 0.8%), protein (3.5 ± 0.1% *v.* 3.1 ± 0.2%), and lactose (4.9 ± 0.1% *v.* 4.7 ± 0.1%) measured in the last milk determination did not differ between HMY and LMY cows ($P = 0.38$, 0.22 and 0.20 respectively).

HMY calves tended to suckle more frequently than LMY calves (1.3 ± 0.3% *v.* 0.7 ± 0.2%, respectively, $P = 0.06$).

Bodyweight

Bodyweight was greater in HMY than LMY calves ($P = 0.05$), and increased with time in all calves ($P < 0.0001$) (Fig. 2). However, ADG was not different between groups, either before or after weaning. There were no differences in ADG after weaning between HMY and LMY calves: 1.3 ± 0.3 and 1.5 ± 0.2 kg/day during the first 7 days ($P = 0.29$), and 0.9 ± 0.7 and 0.9 ± 0.1 kg/day during the first 21 days ($P = 0.72$).

Behaviours

Effects of treatment (HMY or LMY), time, and interactions of treatment and time were observed in the frequency of observations in which calves grazed (Fig. 3*a*; $P = 0.02$, $P < 0.0001$, and $P = 0.02$, respectively). The frequency of grazing was lower in HMY than LMY calves, but in both groups decreased and remained low immediately after weaning. While in HMY calves grazing frequency returned in the last 2 days to a frequency not different from that observed

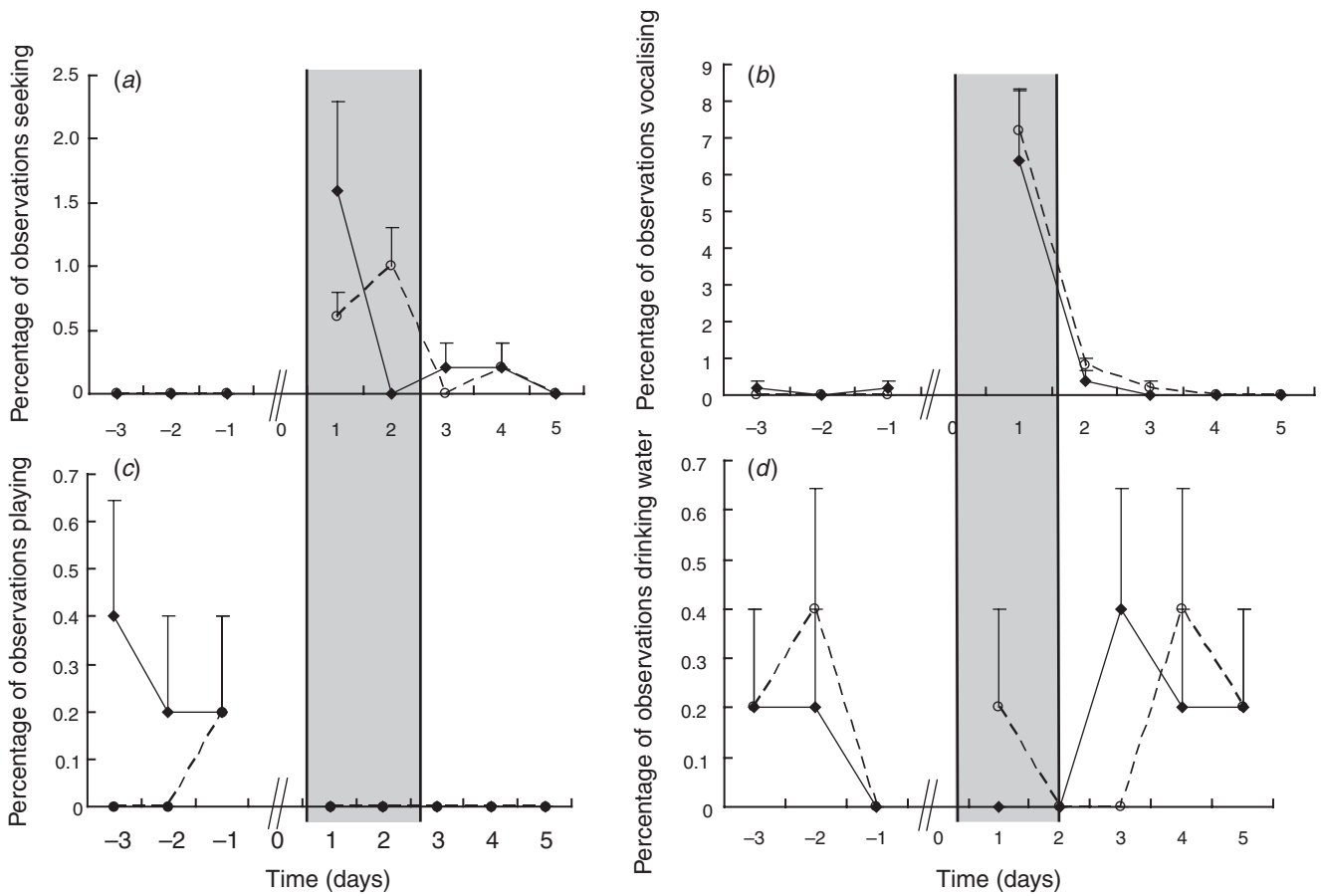

Fig. 4. Frequency of behaviours that were not affected by treatment [high (♦) or low (○) milk yield dams]: (*a*) seeking (affected by time, and with an interaction between treatment and time); (*b*) vocalisations; (*c*) playing; and (*d*) drinking water. The grey area indicates the first 2 days after weaning.

before weaning, in LMY calves the frequency in these last days was greater than that observed before weaning.

The frequency of observations in which calves walked was also affected by treatment (HMY or LMY), time, and interactions of treatment and time were observed (Fig. 3*b*; $P = 0.05$, 0.005 and 0.008, respectively). All calves showed an increase in walking frequency after weaning, but while this increase was maintained for 3 days in HMY, in LMY calves the frequency of this behaviour decreased after the second day after weaning and remained lower than before weaning until day 5.

The frequency of calves ruminating was greater in HMY than LMY (Fig. 3*c*; $P = 0.015$), changed with time ($P < 0.0001$). There was also a tendency to an interaction between treatment and time in the frequency of calves ruminating ($P = 0.07$). The frequency of rumination increased in both groups the second and third day after weaning, and returned to frequencies similar to those observed before weaning on days 4 and 5.

The frequency of standing was lower in HMY than LMY calves (Fig. 3*d*; $P = 0.006$). Frequency of observation in which calves were recorded standing also differed with time ($P < 0.0001$) and tended to be influenced by an interaction between group and time ($P = 0.1$). It was negatively affected by weaning on the first day in LMY and during 2 days in HMY. During the last 2 days the frequency was similar to that observed before weaning in both groups.

The frequency of calves lying tended to be greater in HMY than LMY (Fig. 3*e*; $P = 0.07$), and was affected by time ($P < 0.0001$; increased during the 3 days following weaning), and also tended to be affected by the interaction between group and time ($P = 0.09$).

Fenceline pacing was observed only after weaning. Frequency of observations pacing did not differ between groups, but increased after weaning and decreased later (Fig. 3*f*; $P < 0.0001$). A tendency for an interaction between group and time was observed, which is explained by a sharp increase in pacing frequency the day after weaning. This increase recorded on day 1 was 4-fold greater in HMY than in LMY calves.

Seeking behaviour increased after weaning (Fig. 4*a*; $P < 0.0001$), and there was also an interaction between groups ($P = 0.006$). Although in the LMY group maximum frequency of this behaviour was recorded on day 1, in HMY calves it was observed on day 2. Frequency of vocalisations increased after weaning (Fig. 4*b*; $P < 0.0001$), whereas frequencies of playing (Fig. 4*c*) and drinking water (Fig. 4*d*) were not affected by group or time.

Discussion

Our data confirm that behaviours displayed in response to weaning differ in calves reared by high or low milk producing mothers. The abrupt separation from the cow and forced substitution of the diet did not affect the calves' weight gain, but determined changes in their behavioural patterns, such as an increase in walking activity, vocalisations and fenceline pacing. Differences in most behaviours related to weaning distress were detected, even considering the low number of animals used.

The differences in the behavioural response observed between calves suckling from HMY and LMY cows suggests that the abrupt change in diet provoked by weaning is a component of the distress response. In agreement, it has been previously reported that dairy calves in which milk availability was reduced, increased the duration of sucking in more frequent but shorter bouts and more butting and switching between teats (de Passillé and Rushen 2006). However, it should also be considered that those calves reared by the HMY cows had also greater bodyweights, and were probably more advanced in their physiological and growth maturation stages. Therefore, reactions to weaning may be also related to the different stages of growth in similar aged calves. For instance, suckling, compared with milk ingestion from a bucket, causes larger amounts of oxytocin and insulin in calves (Lupoli *et al*. 2001), suggesting that suckling might stimulate anabolic processes and growth. Thus, the higher growth rate in the calves reared by HMY cows might be associated not only with higher milk or pasture intakes, but also with this feedback physiological system. Also if, as argued by Newberry and Swanson (2008), hormonal changes associated with the onset of cyclicity in the dam and approach to puberty in the young affect neuroendocrine pathways involved in mother–young social attachment, differences in energy balance may confer different states of social attachment in the cow–calf pair.

Altogether, the higher cow's milk yield and calves' liveweight, associated with an increased tendency to suckle and lower grazing frequency in HMY, suggests that milk intake in these calves was greater than in LMY calves. In that case, calves from HMY cows lost the possibility of access to greater amounts of milk. Nonetheless, feeding substitution after weaning appeared to be equally effective in both groups, as growth rate was similar between them. It should be noted that the loss of milk may represent more than just the loss of a source of nourishment. Changes in the physiological mechanisms involved in milk ingestion by the young mammal (Weary *et al*. 2008), as well as on the deprivation of suckling behaviour (de Passillé *et al*. 1993) may contribute to the distress response at weaning when milk is eliminated abruptly. In agreement, working with pigs, Mason *et al*. (2003) suggested that while at weaning the bigger piglets suffered more nutritionally, the lighter ones suffer more emotionally.

The immediate decline in grazing behaviour after weaning may reflect the stress provoked by separation (Price *et al*. 2003). However, in the LMY, but not in the HMY calves, after the initial reduction, grazing frequency increased to a level higher than that observed before weaning. This suggests a rebound effect, possibly related to the need to compensate the loss in grazing time in the LMY calves. The greater ruminating frequency in HMY calves may be associated with greater food consumption compared with LMY calves related to grazing efficiency, rather than frequency of grazing, in animals of higher weight. However, it is interesting to speculate on the increase in rumination observed after weaning. Although at 6 months calves have a completely mature stomach, it seems that the complete substitution of food supply (milking for grazing) determines a greater need for food processing and ruminating activity. Alternatively, the simultaneous reduction in grazing and increase in rumination could result from changes in the pattern of pasture ingestion and pre-processing of the food consumed, reflecting short-term negative impact of weaning

on the calves' emotional state. Another complementary explanation is that rumination is also a resting behaviour, being then a reaction aimed at reducing distress.

Conclusion

Overall, we conclude that the behaviour of 6-month-old beef calves at weaning differed according to their mothers' milk yield, and their developmental growth stage.

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