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Applied Animal Behaviour Science 69 (2000) 177–188

APPLIED ANIMAL BEHAVIOUR SCIENCE

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Effects of early separation on the dairy cow and calf 1. Separation at 6 h, 1 day and 4 days after birth

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Accepted 1 April 2000

Abstract

The aim of this study was to evaluate the effects of age of separation on the behavioural responses of the dairy calf and cow. Calves were separated from their dams 6 h, 1 day, or 4 days after birth ($n = 9$ cow–calf pairs in each of the 3 treatment groups) and behaviour was video and audio taped from 1 h before separation to 21 h after separation. In the hour immediately before separation, we found that the younger calves tended to call and move more in the pen, and spent more time standing than the older calves, but after separation these trends reversed. Calves separated at older ages made significantly more movements in the pen ($P < 0.05$), spent more time standing ($P < 0.05$) and spent more time with the head out of the pen ($P < 0.01$) than calves separated soon after birth. We observed a similar pattern for the cows. Before separation, cows with younger calves moved more frequently about the pen ($P < 0.05$), and called at much higher rates (a mean of 40.7 calls during 40 min for cows on the 6-h treatment, vs. 0.2 calls for cows in the 4-day group; $P < 0.001$). After separation, cows in the 4-day group called at approximately four times the rate of those separated at 6 h or 1 day ($P < 0.01$). Moreover, the calls produced by cows separated later had a significantly higher fundamental frequency ($P < 0.001$) and a lower emphasized harmonic ($P < 0.02$) than the calls of cows separated from calves soon after birth. There was no difference between treatment groups in the other behavioural measures, either before or after separation. Calves separated at older ages tended to require fewer days of treatment for scouring, but calf weight gain and cow milk production did not differ among treatment groups. In conclusion, behavioural responses of both the cow and calf increase in relation to calf age at separation. However, there may be health advantages associated with delayed separation that

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PII: S0168-1591(00)00128-3

compensate for the increased behavioural response.

Keywords: Cattle-maternal-filial bond; Weaning; Vocalization; Welfare

1. Introduction

When a young mammal is separated from its mother at weaning, a number of responses are typically observed (e.g. Fraser et al., 1998). The animal often becomes more active, and much more vocal, especially during the first 24 h after separation. A period of weight loss, or a slowing in the rate of weight gain, is also often observed, accompanied by variable intakes of food and water. The animal also becomes more susceptible to disease and digestive upset. The mother sometimes shows a similar response, including increased activity and vocal behaviour.

For most animals, weaning normally includes both a social and nutritive component, as the young animal simultaneously loses both its mother and its most important source of food and drink. In contrast, the typical North American dairy calf is, in a sense, weaned twice. The calf is normally separated from the cow within a day after birth, but continues to be fed milk from a nipple or pail for another 1–3 months before making the transition to solid food. This procedure may mean that the initial separation from the cow is less traumatic for the young calf than weaning might be for other species, because the nutritive and social components are not superimposed.

In certain domestic species, like the pig, the young are weaned early in order to achieve higher production despite potential welfare problems associated with the practice (Robert et al., 1999). In contrast, dairy producers may be accepting decreased production (especially in calf weight gains; Metz, 1987) to achieve what they feel are welfare advantages associated with early separation. Despite evidence that cows and calves can begin to bond after as little as 5 min of contact after birth (Hudson and Mullord, 1977), separating cow and calf within 24 h of birth is thought to reduce bonding and any distress at separation. Dairy producers have little to gain from separation at less than 4 days of age, as the colostrum-rich milk cannot be sold within this period and early separation simply involves a longer period during which the calves have to be fed by farm staff instead of by the cow.

Despite the practical and animal welfare importance of this question, there has been relatively little work to date on how cows and calves respond to separation. In one example, Hopster et al. (1995) measured physiological responses of eight cows to separation at 2–3 days after birth, and found only a modest increase in heart rate immediately after separation. Only one study to date has monitored responses of both cows and calves to separation at different ages (birth vs. 4 days of age; Lidfors, 1996). This study reported that cows called at similar rates after separation at the two stages, and that calves called more when separated at birth after 4 days with the cow. Unfortunately, the design did not allow a comparison of pre- vs. post-separation responses at both ages, behaviours were scored for only 2 h/day, and no spectrographic analysis of the calls was attempted.

The aim of the current study is to determine the effect on the cow and calf of separation at three ages encompassing the range at which separation typically occurs on North American and European dairy farms. Response to separation was assessed using vocal and other behavioural measures identified as promising in preliminary analysis. We also tested the effect of the treatment on calf weight gain, calf health and cow milk production.

2. Materials and methods

This experiment was conducted at the University of British Columbia Dairy Education and Research Centre in Agassiz, British Columbia. Holstein cow–calf pairs were randomly assigned in blocks to three treatment groups involving separation from the dam at: 2–6 h after birth (nominally 6 h), 20–24 h after birth (1 day), and 92–96 h after birth (4 days). Each treatment group consisted of two cows in their first lactation and seven in a second or later lactation, for a total of nine cows per treatment.

Calving occurred in individual indoor maternity pens bedded with sawdust and straw, and cows and calves were kept together in these pens. Cows were taken to the parlour to be milked twice daily (at approximately 08:30 and 16:00), but at other times calves were free to suckle. All calves were offered 2 l of colostrum by bottle during each of two feedings within 24 h of birth. Calves in the 6-h treatment group received both colostrum bottles after separation from the cow, but calves in the other groups received these feedings before separation. Cows were fed both tall fescue hay and a total mix ration of grain, corn and grass silage for ad libitum intake, and had free access to water from a bowl.

Video cameras (Panasonic WV-BP310) were positioned to record each maternity pen. Output from the cameras was recorded continuously (Sony SLV-675 HF VCR) for a 40-min period immediately before separation (cow and calf), and again for 40 min at 0, 3, 6, 9, 12, 15, 18 and 21 h after separation (cow only). Calls were recorded using the same VCR and a Beyer Dynamic MCE 86 N(C)S microphone (suspended from the ceiling approximately 2 m above the floor of the pen) connected through a Symetrix SX202 preamplifier.

At separation, calves were moved more than 100 m from the dam to a calf barn where they were housed in individual wooden pens (1.5×1.2 m^2) bedded with sawdust. Calves were bucket-fed 1.5 l whole milk twice daily thereafter. Calves were video and audio recorded for the first 21 h after separation using the same equipment, microphone placement and schedule described for the cows. Male calves were not followed beyond the first 21 h after separation. Heifer calves ($n = 16$) were weighed on the day of birth, 10 days of age and at 3 weeks of age. Any indications of diarrhea and any treatment were noted daily.

2.1. Behavioural observations

All behaviours were scored from videotape. Before separation, the following calf behaviours were scored: time standing (s), number of movements (all four feet move at

least once without pause), and number of calls. After separation, we also recorded the time (s) calves spent with their head out of the pen (tip of the nose outside one of the pen openings). The design of the maternity pens did not allow calves to stick their heads outside, so this measure could not be recorded before separation. We also recorded the frequency with which calves sniffed the bedding, and sniffed or licked the walls of the

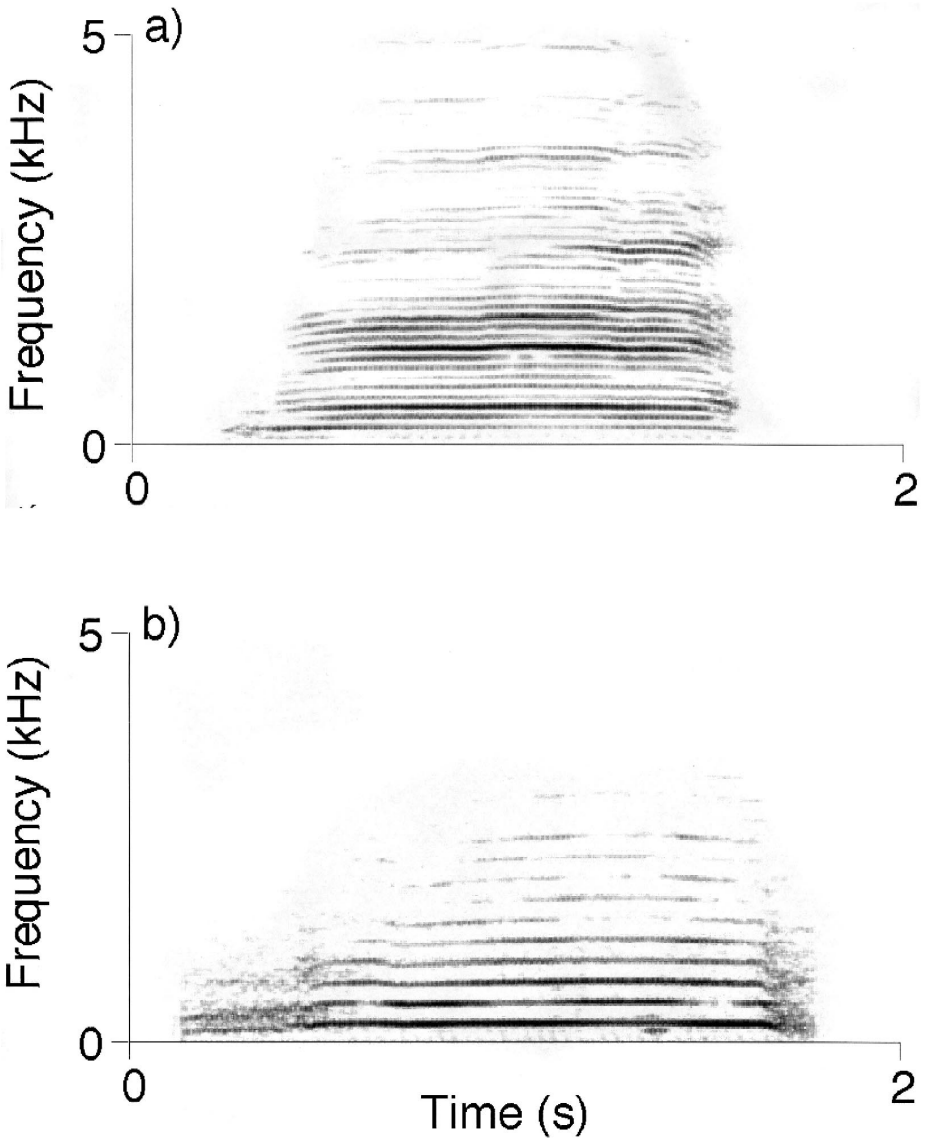

Fig. 1. Frequency spectrograms of calls produced after separation by (a) the calf, and (b) the cow.

pen, but preliminary analysis showed no treatment effects for these variables so they are not discussed further.

For cows, we measured (before and after separation) time standing (s), time with head out of the pen (tip of the nose over the wall of the pen) (s), number of movements (defined above), and number of calls. We also measured the time spent eating, drinking and ruminating, as well as the frequency with which cows sniffed the bedding, and sniffed or licked the walls of the pen, but again preliminary analysis showed no treatment effects for these variables and they are not discussed further.

2.2. Spectral analysis

Calf and cow calls consist of harmonic stacks (Kiley, 1972), much like those in voiced components of human speech. Examples of post-separation calf and cow calls are shown in Fig. 1. To provide a more complete description and comparison of these calls, spectrographic analysis was performed. The first call in every 5-min segment of each 40-min observation period was digitized. If another calf's call or other noise interrupted the call, or if it was too soft to distinguish from the background noise, the next call was selected. Calls were digitized at a sample rate of 22 kHz and at 16-bit resolution using CANARY 1.2 (Cornell Laboratory of Ornithology) sound analysis software. Call duration (s) was measured using the time-waveform display. The fundamental frequency (Hz), number of the loudest harmonic (where the fundamental $= f^0$), and sound pressure level (SPL) of that harmonic were measured using the frequency spectrum display. In Fig. 1, the loudest harmonic appears as the darkest band, and the fundamental frequency is equal to the frequency difference between adjacent bands. Because the calls vary little with time, these measures provide a reasonable description of the call. Differences in SPL are calculated in decibels (dB).

Table 1
Mean ($\pm$SE) responses per 40-min. period of calves before and after separation from the cow 6 h, 1 day or 4 days after birth ($n = 9$ in each group). The post-separation means include observations at 9, 12, 15, 18 and 21 h after separation. *P*-values are for the linear effect of treatment in the general linear model used to test differences in the dependent variables. *P*-values for non-linear effects are indicated in the text where significant

Period	Variable	Treatment			*P*
		6 h	1 day	4 days	
Pre-separation	calls (no.)	9.1 ± 4.3	9.4 ± 9.4	0.3 ± 0.3	> 0.1
	moves (no.)	15.8 ± 3.6	3.8 ± 1.6	13.7 ± 7.5	> 0.1
	stand (s)	830 ± 220	489 ± 170	553 ± 263	> 0.1
Post-separation	calls (no.)	12.9 ± 4.7	7.3 ± 3.4	27.3 ± 11.3	> 0.1
	duration (s)	1.26 ± 0.10	0.98 ± 0.07	1.21 ± 0.09	> 0.1
	fundamental (Hz)	124 ± 5	103 ± 7	120 ± 6	> 0.1
	harmonic (no.)	4.6 ± 0.9	1.9 ± 0.6	3.1 ± 0.7	> 0.1
	head out (s)	36 ± 11	43 ± 21	209 ± 54	< 0.01
	moves (no.)	6.4 ± 1.4	8.6 ± 3.4	22.6 ± 7.0	< 0.05
	stand (s)	422 ± 57	316 ± 70	659 ± 94	< 0.05

2.3. Statistical analysis

For all dependent variables, the linear (1 *d.f.*) and non-linear (1 *d.f.*) effects of calf age at separation were tested using analysis of variance (residual error = 24 *d.f.*). Test statistics for the non-linear term are reported only where significant. Treatment differences were compared before separation and after separation. Post-separation values used in the analysis were averages across the eight post-separation observations. Differences across the eight post-separation observations are illustrated, but treatment differences were not statistically tested at each session. Standard errors of the mean are reported as a measure of dispersion for comparisons between means, but standard deviations accompany those means reported for descriptive purposes.

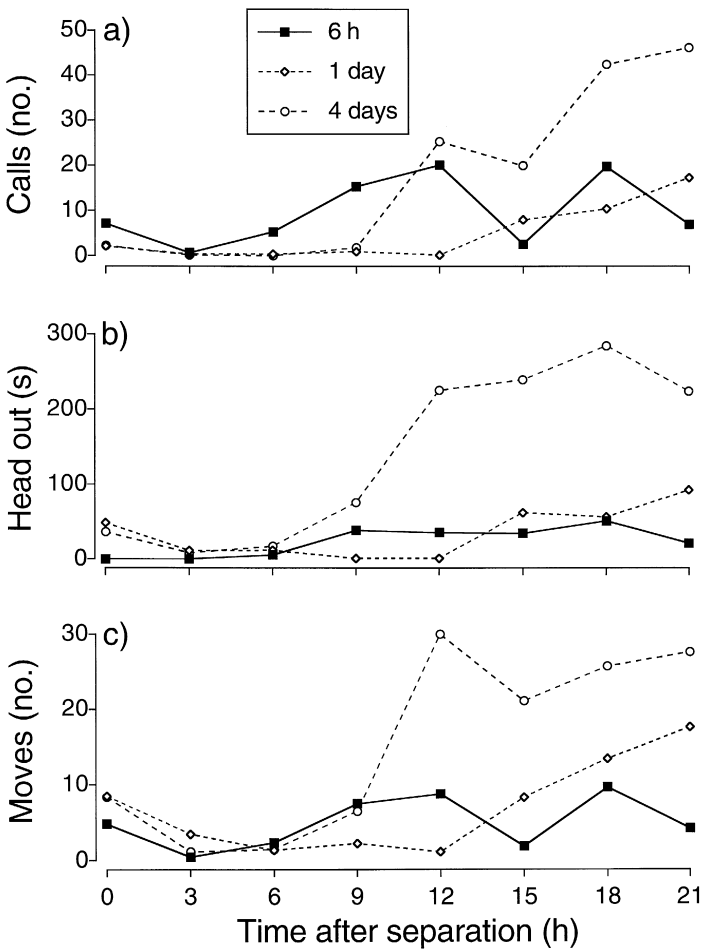

Fig. 2. Calf response as a function of time since separation. Mean responses are shown for (a) number of calls, (b) time spent with head out of pen, and (c) number of movements, and are shown separately for calves in each of the three treatments (separation from cow at 6 h, 1 day or 4 days, $n = 9$ calves per treatment). Treatments are compared statistically across the post-separation periods in Table 1.

3. Results

3.1. Calf response

Calves in all three treatments behaved similarly before separation, although there was some tendency for calves in the 1-day treatment to move less frequently than calves in the other two groups (Table 1). Calves were relatively quiet during the first few hours after separation, with most response happening after 9 h of separation from the cow (Fig. 2). For this reason, subsequent analysis of the post-separation calf response did not include observations 0, 3 and 6 h after separation.

On average, calves separated at older ages spent significantly more time with the head out of the pen, made more body movements and spent more time standing than did younger calves during the post-separation observations (Table 1). Time standing was particularly high for calves in the 4-day group, and this difference was reflected in a significant non-linear term in the statistical analysis ($P < 0.05$). To control for these differences, we reanalyzed behaviours as a percentage of the time spent standing. Percentages increased with age at separation for both head out of the pen ($8 \pm 2\%$ for the 6-h group to $30 \pm 5\%$ for the 4-day calves; $P < 0.001$) and number of moves ($1.5 \pm 0.2\%$ for the 6-h treatment to $2.4 \pm 0.5\%$ for the 4-day group; $P < 0.05$).

There was no significant difference in call rate between the three treatment groups before or after separation, although calves in the 4-day group called least before separation and most after separation. The pre-separation calf calls were very quiet, such that only the calls of four calves (all from the 6-h treatment group) could be subjected to

Table 2
Mean ($\pm$SE) responses per 40-min. period of cows before and after separation from their calf 6 h, 1 day or 4 days after birth ($n = 9$ in each group). The post-separation means include observations at 0, 3, 6, 9, 12, 15, 18 and 21 h after separation. *P*-values are for the linear effect of treatment in the general linear model used to test differences in the dependent variables. *P*-values for non-linear effects are indicated in the text where significant

Period	Variable	Treatment			*P*
		6 h	1 day	4 days	
Pre-separation	calls (no.)	40.7 ± 10.0	8.0 ± 4.0	0.2 ± 0.2	< 0.001
	duration (s)	0.84 ± 0.15	0.53 ± 0.06	–	> 0.1
	fundamental (Hz)	127 ± 34	88 ± 11	–	> 0.1
	harmonic (no.)	0.6 ± 0.3	1.2 ± 0.3	–	> 0.1
	head out (s)	0.0 ± 0.0	1.1 ± 0.7	2.3 ± 2.3	> 0.1
	moves (no.)	9.7 ± 2.6	5.8 ± 1.8	3.9 ± 1.1	< 0.05
	stand (s)	1130 ± 278	1487 ± 340	1542 ± 324	> 0.1
Post-separation	calls (no.)	7.9 ± 0.1	7.4 ± 0.2	34.8 ± 0.2	< 0.01
	duration (s)	1.24 ± 0.15	1.11 ± 0.15	1.41 ± 0.13	> 0.1
	fundamental (Hz)	121 ± 10	129 ± 19	206 ± 14	< 0.001
	harmonic (no.)	1.6 ± 0.6	0.3 ± 0.2	0.2 ± 0.1	< 0.02
	head out (s)	27 ± 11	23 ± 7	55 ± 15	> 0.1
	moves (no.)	10.0 ± 1.6	10.4 ± 1.9	10.1 ± 1.9	> 0.1
	stand (s)	1400 ± 111	1664 ± 137	1464 ± 139	> 0.1

the detailed sound analysis. These calls were, on average (±SE) 1.23 ± 0.36 s in duration, with an average fundamental frequency of 86 ± 2 Hz, and with the average emphasized harmonic of 0.6 ± 0.6.

In contrast, post-separation calls were an average of 30 dB louder than the pre-separation calls measured. The calls (for the 6-h calves) were similar in duration, but higher in fundamental frequency and emphasized harmonic after separation than before. However, there were no statistically significant differences between the treatment groups in these features of the post-separation calls.

Heifer calves weighed on average (±SD) 41.9 ± 4.2 kg at birth, gained 0.13 ± 0.27 kg/days over the following 10 days, and 0.28 ± 0.11 kg/days over the first 3 weeks of

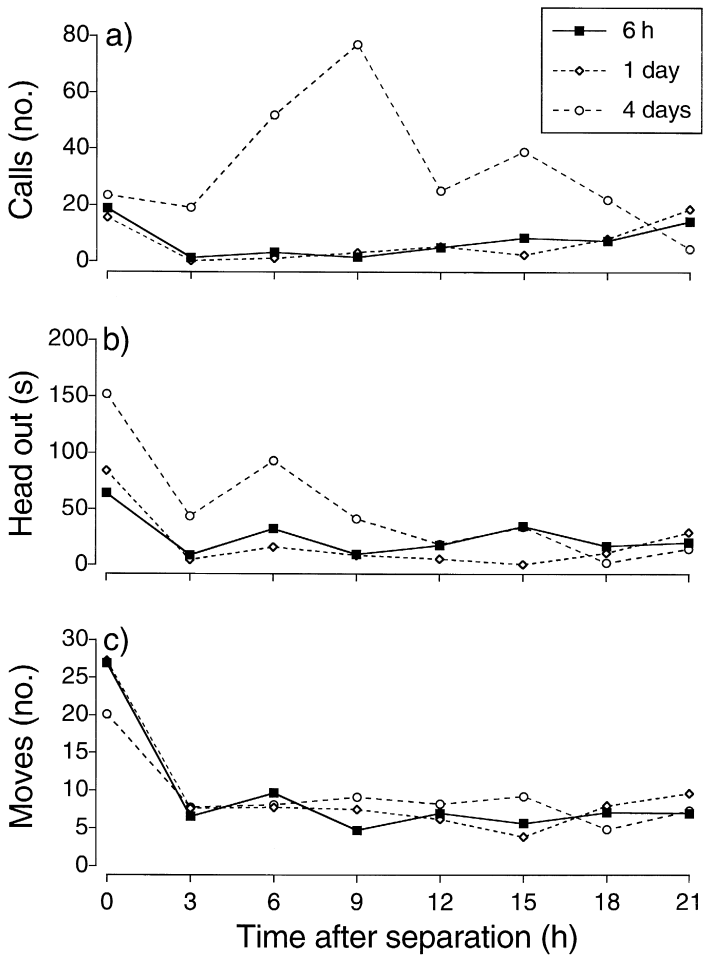

Fig. 3. Cow response as a function of time since separation. Mean responses are shown for (a) number of calls, (b) time spent with head out of pen, and (c) number of movements, and are shown separately for cows in each of the three treatments (separation from calf at 6 h, 1 day or 4 days, $n = 9$ cows per treatment). Treatments are compared statistically across the post-separation periods in Table 2.

life. There were no statistically significant effects of age of separation on birth weight or weight gains. The number of days calves were treated for diarrhea tended to decline with age of separation ($P = 0.08$): calves separated at 6 h were treated on average ($\pm$SE), 5.5 ± 1.7 days during their first 4 weeks of life, compared to 4.0 ± 0.7 and 2.0 ± 1.2 days for the 1-day and 4-day treatment groups.

3.2. Cow response

During the observation session immediately before separation, cows with younger calves were much more vocal: cows with the youngest calves produced, on average, more than 40 calls during this 40-min period, while cows with the 4-day old calves rarely vocalized at all (Table 2). There were no significant differences in the duration, fundamental frequency or emphasized harmonic of these calls for the 6-h and 1-day groups (our sample of calls from the 4-day group was too small to allow comparison). Cows with younger calves were more likely to move around the pen, but there was no other effect of treatment on cow behaviour before separation.

Cows showed some response to separation even within the first post-separation observational period (Fig. 3). Vocal response peaked at 9 h after separation, at least for cows in the 4-day group (Fig. 3a), but time spent with head out of the pen and number of moves were both highest immediately after separation (Fig. 3b,c).

After separation, the effect of the age treatment on vocal behaviour was reversed in comparison to pre-separation values: cows separated from their calves 4 days after birth called at a higher rate than cows separated 1 day or 6 h after birth. Moreover, the calls produced by the cows with older calves were higher in fundamental frequency and lower in emphasized harmonic. There was also an effect of age at separation on call loudness ($P < 0.01$): calls from cows separated 4 days after birth were 12 dB louder than those from the 1-day group and 19 dB louder than those from the 6-h group. There was no other effect of treatment on cow behaviour after separation.

Milk production after separation (days 5–14 of lactation) averaged ($\pm$SD) 35.6 ± 7.7 kg/day. There was no effect of treatment on milk production or the incidence of mastitis.

4. Discussion

This study provides the first experimental evidence of a stronger behavioural response to separation at older ages than when separation occurs soon after birth. Specifically, we found that after separation, older calves spent more time with their head out of the pen, made more body movements and spent more time standing than did younger calves. The differences in head position and movements remained significant even after expressing them as a proportion of the time the calf was standing.

In contrast, Lidfors (1996) found little effect on calf behaviour following separation at 96 h. However, calves were only observed during the first 2 h after separation, a time when we found that they are relatively inactive. The results that we report are due to differences between treatment groups 9–21 h after separation.

Like Lidfors (1996), we found that the younger animals were more vocal and active during the pre-separation observations — the hours after birth are a time of relatively intense cow–calf interaction. We also show, however, that these pre-separation differences (i.e. higher frequencies of vocal and other behaviours at the younger ages) are reversed after separation (i.e. higher frequencies of vocal and other behaviours at older ages).

We also noted this reversal in treatment effects on cow behaviour, especially cow vocalizations, following separation. Cows with calves 2–6 h old were highly vocal, producing short duration, quiet calls. Once calves were 1 day old, cows called only about 20% as frequently, and rarely vocalized at all by the time calves were 4 days old. In contrast, call rate by cows after separation was highest in the 4-day group. Cows in this group showed a 174-fold increase in call rate after separation, persisting several hours after separation. These results are not consistent with Hopster et al. (1995, p. 5), who concluded that the ''acute response of multiparous dairy cows to removal of their calves is moderate and short-lived'', but they studied calves for only 15 min after separation. The strong response we observed is more consistent with Hudson and Mullord (1977) who showed that separation is distressful for cows even if they have been allowed only a very short period of contact with the calf. Lidfors (1996) also reported an increase in call rate of cows following separation from the calf 4 days after birth. Previous calving experience is thought to affect maternal behaviour (Edwards and Broom, 1982) and could also affect response to separation. Unfortunately, our sample of heifers was too small to test differences due to parity.

Our study was designed to determine acute behavioural effects of age of separation, but we also measured cow milk production, and for heifer calves, weight gain and incidence of diarrhea. We found no treatment differences in calf gains or cow milk production, but did find that calves which spent more time with the cow before separation tended to experience fewer bouts of diarrhea during the first 3 weeks of life. Presumably, the older calves consumed more colostrum, and this, plus any maternal influence on absorption (Stott et al., 1979), may have allowed calves kept with their mothers to acquire higher immunoglobulin concentrations than those separated early, as has been found in previous work (Petrie, 1984). Also, immunoglobulins in the colostrum may continue to bathe the gut, thus providing passive protection from infection after immunoglobulin absorption has occurred (Leece, 1975).

Although we detected no advantage in weight gains associated with delayed separation, other studies have found that calves kept with cows show higher weight gains. For example, Metz (1987) showed that calves allowed to suckle freely for 10 days after birth gained weight at twice the rate of calves separated from the cow and fed limited quantities of milk by bucket. Moreover, the difference in gains persisted for at least 2 months. Krohn et al. (1999) reported that calves kept with the dam for 4 days showed twice the rate of gain as calves that had been separated, even when the calves kept with the cow were not allowed to suckle. Calves kept with the dam also showed a reduced latency to defecate and urinate following birth, probably as a result of ano-genital licking by the cow (Metz and Metz, 1986).

We found no differences in cow milk production following separation. Metz (1987) also reported no difference in milk production after separation (days 16–110) between

cows separated from calves at 10 days vs. those separated at birth. Several days of suckling by calves may have health benefits for the cow, such as reducing the retention of foetal membranes and the incidence of mastitis (Krohn et al., 1990), and may actually reduce the calving to conception interval (Metz, 1987).

In conclusion, cows and calves showed vocal and other behavioural responses to separation at 6 h, 1 day and 4 days post-partum, but response was strongest after longer periods together. These results indicate that both cow and calf experience greater distress with later separation. However, other literature suggests that later separation confers health benefits to both the calf and cow. Judging the best date for the animals welfare will require a balancing of these factors.

Acknowledgements

We are grateful to Erin Bell for help in data collection and tape analysis, to Frances Flower, Jennifer Jasper and Cassandra Tucker for their comments on previous drafts of this manuscript, and to David Fraser for his many contributions at all stages of this study. We also thank the staff of the UBC Dairy Education and Research Centre for their help with the experiment and care of the animals. This work was supported by NSERC through the Industrial Research Chair in Animal Welfare, and by contributions from the Dairy Farmers of Canada, the Cattle Industry Development Fund, the BC Dairy Foundation, the BC SPCA, members of the BC VMA and many other donors listed on our web site at www.agsci.ubc.ca/animalwelfare.

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