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# Responses of dairy cows and calves to each other's vocalisations after early separation

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**Abstract**

Current commercial dairy practice involves the removal of the calf from the dam within the first day of life. Both vocalize after separation. The aim of this study was to determine if cows and calves respond to each other's calls after separation and whether they could distinguish their own calf's or dam's calls from another calf's or cow's calls. The study was carried out on 12, first to fourth parity, Holstein cow-calf pairs. Immediately after calving, the cow and calf were moved to a single pen. Each calf was separated from its dam 24 h later and placed in an individual calf pen in another building. The cow remained in the home pen. During the next 24 h, sample calls were recorded from the cow and calf. Four or five representative calls from each cow and calf were edited together to form playback sequences for each animal. For each call sequence, a paired white-noise sequence was generated. At 24 h after separation, the cow and calf were subjected to four playback sequences in two pairs; own calf or dam and white noise, other calf or other cow and white noise. Cows responded more to calf vocalisations than to white noise during and after playback. They had a greater heart rate (HR) change (call = 16.5%, noise = 7.3%) and increased head movements (call = 1.1 $min^{-1}$, noise = −0.5 $min^{-1}$) and ear movements (call = 8.6 $min^{-1}$, noise = 1.9 $min^{-1}$). However, cows only decreased head movements when differentiating between own calf calls and other calf calls. Calves showed more head movements (call = 3.8 $min^{-1}$, noise = 1.5 $min^{-1}$) and less ear flicks (call = −1.4 $min^{-1}$, noise = 1.5 $min^{-1}$) during playback of cow calls compared to white noise. They also showed greater HR change (own = 15.6%, other = 5.8%) and tended to show more ear movements (own = 1.9 $min^{-1}$, other = −0.7 $min^{-1}$) and less head movements (own = −0.3 $min^{-1}$, other = 0.5 $min^{-1}$) during playback of own mother calls compared with other cow calls. The apparent

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poor ability of dairy cows to preferentially respond to calls from their own calf may have been because separation is carried out before cows have been able to learn these calls; calves are rarely vocal during the first few hours of life. Dairy calves responded subtly to cow calls, but responses were greater to calls from their own dam. During the pre-separation period, the cow is vocal towards the calf and under natural conditions, overt responses to cow calls could increase risk of predation. Dairy calves are, therefore, capable of individual recognition based on auditory cues at a very early age.


*Keywords:* Cattle mother–offspring bond; Vocalisations; Recognition; Welfare

## 1. Introduction

On conventional commercial dairy farms, it is standard practice to separate newborn calves from their mothers within the first 24 h of life. The calves are then reared artificially by bottle- or bucket-feeding milk up to weaning at between 4 and 10 weeks of age (Broom and Leaver, 1978). This contrasts sharply with natural behaviour in free-living herds, where the cow will isolate herself from the herd before calving, and then keep her newborn calf hidden in the undergrowth for 2 to 10 days before it is introduced into the herd (Schloeth, 1961; Baskin and Stepanov, 1993; Lidfors et al., 1994). Dams then begin to leave their calves in 'crèches' or groups at about 2 weeks old but one or two cows remain in sight (Kilgour and Dalton, 1984; Baskin and Stepanov, 1993). Calves continue to suckle regularly until either a nutritive deficiency causes the dam's lactation to cease or she gives birth to another calf. However, even then, the yearling calf may continue to suckle from its dam (Veissier et al., 1990).

Early separation in cattle has only received limited attention (Hudson and Mullord, 1977; Kent and Kelly, 1987; Lidfors, 1996; Weary and Chua, 2000; Flower and Weary, 2001) and most of this research has focused on how separation affects the cow, rather than the calf. It has been shown that cows, in particular multiparous cows, find early separation stressful (Phillips, 1993) and that even 24 h after separation cows can still show behavioural signs of distress (Hudson and Mullord, 1977; Kent and Kelly, 1987). However, others report the response to separation being short-lived and mild (Hopster et al., 1995). For the calf, separation prior to natural weaning also appears to evoke increased vocalisation rates, activity and catecholamine concentrations (Lefcourt and Elsasser, 1995; Lidfors, 1996).

Taken as a whole, these data indicate that bonding has already occurred by the time of separation. Indeed, the first few hours following parturition appear to be critical in establishing mother–infant bonds (Edwards and Broom, 1982), although there is debate as to when and how long this period lasts. Some data suggest that 5 min of contact with a calf immediately after birth is sufficient to form a strong maternal bond (Hudson and Mullord, 1977), whereas others indicate that bonding may require contact for up to 3 h (Sluckin and Herbert, 1986).

The formation of the cow–calf bond during these first few hours after birth may be accompanied by the cow and calf learning to recognize one another. Olfactory (Porter et al., 1991; Schaal and Marlier, 1998), visual (Alexander and Shillito, 1977a,b; Ruizmiranda,

1992) and auditory (Kent, 1987; Weary et al., 1996) cues are implicated in early recognition in other species and it is known that 3–5-week-old calves are able to recognize their mothers by auditory cues alone (Barfield et al., 1994). It has also been demonstrated that both cows and calves vocalise in response to separation (Weary and Chua, 2000; Flower and Weary, 2001), even when separated 24 h after birth. However, it is not known whether these calls serve to elicit an appropriate behavioural response from the recipient after such early separation or if they can be used as cues for recognition. Therefore, the aims of this study were to determine if:

(1) calves respond to calls produced by a cow that has been separated from its calf;
(2) cows respond to calls produced by a calf that has been separated from its mother;
(3) cows respond differentially to calls of their own calf;
(4) calves respond differentially to calls of their own mother.

## 2. Materials and methods

### 2.1. Animals and housing

This study was conducted on 12 Holstein dairy cows, ranging in age from first to fourth parity, and their 12 calves—6 males, 6 females—between June and August 1999, at the University of British Columbia's Dairy Education and Research Centre, Agassiz, Canada. Individuals were selected for the experiment as they approached calving. Two weeks prior to expected calving date, the experimental cows were separated from the main herd and were group-housed with 3–8 other pre-parturient cows in a sand-bedded pen (120 $m^2$), with ad libitum access to water and a total mix ration of grain, maize silage and grass silage.

Immediately after calving, the cow and calf were moved to an individual, straw-bedded maternity pen (4.3 m × 3.0 m), until the time of separation. The pen had concrete flooring, covered by a deep layer of straw that was cleaned and renewed daily. Cows were fed twice daily on the forage ration whilst tall fescue hay and water were available ad libitum. Cows were removed from the pen and milked in the parlour with the rest of the herd at 08:30 and 16:00 h daily, for approximately 30 min on each occasion, during which time the calf remained in the pen. All calves were allowed to suckle from their mothers without restriction but were also bottle-fed 2 l of colostrum within 12 h of birth. Each calf was separated from its dam at 24 ± 12 h after parturition, at 12:00 h and placed in an individual calf pen (1.5 m × 1.2 m) in a separate building preventing visual, auditory or olfactory contact with the dam. The sides of the calf pens were solid, with openings on the front and back for access to food and water. The pens were positioned so that neighbouring calves could see but not physically contact one another. The concrete floor was covered with a thick layer of sawdust. After separation, calves were fed milk from a bucket twice daily (5% of their body weight on each occasion). Calf starter and hay were available ad libitum. Cows remained in the maternity pen for 30 h before returning to the herd. Calves remained in calf pens until weaning age (8–10 weeks) when they were group-housed with similar aged calves.

### 2.2. Experimental procedure

During the 24-h period after separation, sample vocalisations from the cow and the calf were recorded, using a hand-held Beyer Dynamic MCE86 N microphone and a Sony DAT TCD-7 digital audio tape-recorder. As illustrated by Flower and Weary (2001), the most suitable times to record cow vocalisations, in terms of vocalisation rate, are immediately post-separation and at approximately 18 h after separation. The most suitable time to record calf vocalisations is at approximately 18 h after separation, before the morning feeding. Indeed, the calf is silent immediately after separation. Thus for each cow–calf pair, we recorded the cow's calls immediately after separation, and recorded the calf's calls 18 h later. These recordings were edited on a laptop computer (Macintosh Powerbook 145) using SoundEdit16 (version 2, Macromedia) sound analysis software. Representative calls—i.e. calls which were of typical amplitude and duration based on amplitude profiles and typical frequency based on subjective assessment—were selected from each cow and calf. Four or five calls were digitally spliced together to form separate 20 s playback sequences from each animal, that were free from extraneous noise. For each call sequence, a paired white-noise sequence was generated, with an identical pattern of changes in amplitude with time.

All playbacks were carried out with the calves and cows in the pens that they had been kept in since separation. The cows were therefore tested in isolation from other cows, whereas the calves were tested in the calf barn with other calves present in adjacent pens. None of the experimental animals had been exposed to playback before their own playback series was complete. At 24 h after separation, the cow and calf were each fitted with Polar Vantage NV heart rate (HR) monitors (Polar Electro Oy, Kempele, Finland). One hour after fitting the HR monitors, each cow was subjected to four playback sequences in two pairs; own calf and white noise, other calf and white noise. Similarly, each calf was also subjected to four playback sequences in two pairs; own cow and white noise, other cow and white noise. Eight different playback orders were possible (Table 1) and these were balanced across the experiment.

Playback was carried out when cows were standing and when calves were lying, as these were the predominant postures at the time of testing. During playback, a speaker (Fostex

Table 1
The possible orders of playback of the paired sequences of calls and white noise

| | First paired playback sequence | | Second paired playback sequence | |
|---|---|---|---|---|
| | Playback 10 min gap | Playback 30 min gap | Playback 10 min gap | Playback 30 min gap |
| 1 | Noise | Own | Noise | Other |
| 2 | Noise | Own | Other | Noise |
| 3 | Noise | Other | Noise | Own |
| 4 | Noise | Other | Own | Noise |
| 5 | Own | Noise | Noise | Other |
| 6 | Own | Noise | Other | Noise |
| 7 | Other | Noise | Noise | Own |
| 8 | Other | Noise | Own | Noise |

6301B) was positioned at the front of the pen, between 2 and 4 m away from cows and 1 m away from calves. The playback sequences were played directly from the laptop computer with peak amplitude of 90 dB (C weighted) at 1 m—similar to amplitudes measured directly from the cows and calves themselves.

HR and behaviour were recorded continuously during 3 periods per individual playback sequence. These were: 1 min immediately before playback; the 20 s of playback; 2 min immediately after playback. Within paired sequences, each 3 min and 20 s experimental session was separated by a gap of 10 min. Each pair of playback sequences was separated by a gap of 30 min. Cows were recorded using a camcorder (Sony CCD-TR101), and the following behaviours were later scored from tape in slow-motion and using the timer superimposed on the tape, by the same observer at all times, for each of the 3 periods per playback:

(1) Number of ear movements—the cow's ear is moved slowly either backwards or forwards away from original position.
(2) Number of ear flicks—the cow's ear moves quickly away from and back to original position in a single movement.
(3) Number of head movements—the cow's head is moved slowly up, down or to one side away from original position.
(4) Number of calls given by the cow.
(5) Proportion of time spent oriented towards the speaker—the cow has head oriented towards the loudspeaker.
(6) Proportion of time spent oriented elsewhere—the cow has head oriented elsewhere, other than to the loudspeaker.
(7) Proportion of time spent walking—the cow is engaged in locomotor behaviour.
(8) Proportion of time spent eating—the cow is chewing forage ration or hay.
(9) Proportion of time spent drinking—the cow is drinking water from the trough.
(10) Proportion of time spent grooming—the cow is engaged in self-directed licking/nuzzling.

Calf behaviour was recorded in the same way, except that only the first six variables were recorded, as a pilot study had revealed the other measures to be irrelevant—calves remained lying and did not eat, drink or groom during the test. In addition, we measured the proportion of time spent lying with head raised, defined as the calf lying with head lifted above the floor.

HR data were downloaded via a Polar Advantage Interface (Polar Electro Oy, Kempele, Finland) onto a PC for data handling using Polar Precision Performance Software (version 5.04, Polar Electro Oy, Kempele, Finland). Mean HR values and peak HR values were calculated for each of the three periods.

### 2.3. Statistical analysis

The before-playback measures were used as a baseline, and thus subtracted from the during- and after-playback measures, which served as the dependent variables in the statistical analysis. The effect of call (i.e. vocalisation versus noise) on these variables was tested using a general linear model that included, in order, subject (11 d.f.), own (i.e. calls

from own calf or cow versus other; 1 d.f.) subject*own interaction (11 d.f.), call (1 d.f.) and call*own interaction (1 d.f.). The last two terms were tested against the residual error (22 d.f.). This interaction term was never significant, and is, therefore, not reported below. This complete model provides the most sensitive test of the effect of call, but the test of own only makes biological sense when tested with the vocalizations and not noise. Thus this effect was tested considering only responses to actual calls, using a general linear model that first included subject (11 d.f.), and tested the own term (1 d.f.) against the residual error (11 d.f.).

## 3. Results

Cows responded more to calf vocalisations than to white noise during and after playback (Table 2). Although there were no differences in the proportion of time spent drinking and grooming or in the number of ear flicks performed, cows had a greater HR response, performed more ear and head movements, spent more time walking and oriented towards the speaker and spent less time eating when played calf vocalisations compared to when played white noise. Cows showed fewer head movements ($F_{1,11} = 4.9$, $P < 0.05$) in response to their own calf's calls (Fig. 1a) but did not vary in response in terms of number of ear movements and flicks, HR responses, time spent oriented to the speaker, standing, walking, drinking, feeding or grooming.

Calves also responded more to cow vocalisations than to white noise. They were more likely to move their head (call $= 3.8 \pm 0.8$ min$^{-1}$, noise $= 1.5 \pm 0.7$ min$^{-1}$, $F_{1,22} = 10.8$, $P < 0.01$) and tended to flick their ears less (call $= -1.4 \pm 0.8$ min$^{-1}$, noise $= 1.5 \pm 1.2$ min$^{-1}$, $F_{1,22} = 3.1$, $P < 0.1$) and show a higher peak HR response (call $= 20.8 \pm 3.1\%$, noise $= 16.3 \pm 2.3\%$, $F_{1,22} = 3.7$, $P < 0.1$) during playback of cow calls than during playback of white noise. After playback, calves had a greater change in the

Table 2
Mean ± S.E. behavioural and HR responses of cows during and after playback of calf vocalisations or white noise

| Measure (change from pre-playback levels) | During playback | | | After playback | | |
|---|---|---|---|---|---|---|
| | Call | Noise | *F*-value | Call | Noise | *F*-value |
| Mean HR (%s) | 3.7 ± 2.0 | −1.7 ± 0.7 | 9.40** | 0.5 ± 0.3 | −0.4 ± 0.2 | 1.39 |
| Peak HR (%) | 11.7 ± 3.5 | 2.5 ± 0.9 | 9.20** | 16.5 ± 3.8 | 7.3 ± 1.5 | 10.66** |
| Ear movements (number/min) | 8.6 ± 2.0 | 1.9 ± 1.3 | 9.40** | 5.9 ± 2.7 | 2.7 ± 1.8 | 0.42 |
| Head movements (number/min) | 3.3 ± 1.0 | −0.1 ± 0.6 | 25.73*** | 1.1 ± 0.5 | −0.5 ± 0.4 | 6.97* |
| Proportion of time spent walking | 0.06 ± 0.01 | −0.01 ± 0.01 | 15.79*** | 0.02 ± 0.01 | −0.01 ± 0.01 | 4.83* |
| Proportion of time spent oriented towards loudspeaker | 0.47 ± 0.06 | 0.23 ± 0.07 | 9.80** | 0.33 ± 0.05 | 0.05 ± 0.04 | 17.92*** |
| Proportion of time spent eating | −0.28 ± 0.08 | −0.07 ± 0.04 | 11.27** | −0.25 ± 0.09 | −0.03 ± 0.03 | 6.86** |
| Vocalisations | | | | 0.2 ± 0.2 | −0.1 ± 0.1 | 3.42+ |

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.
+ $P < 0.1$.

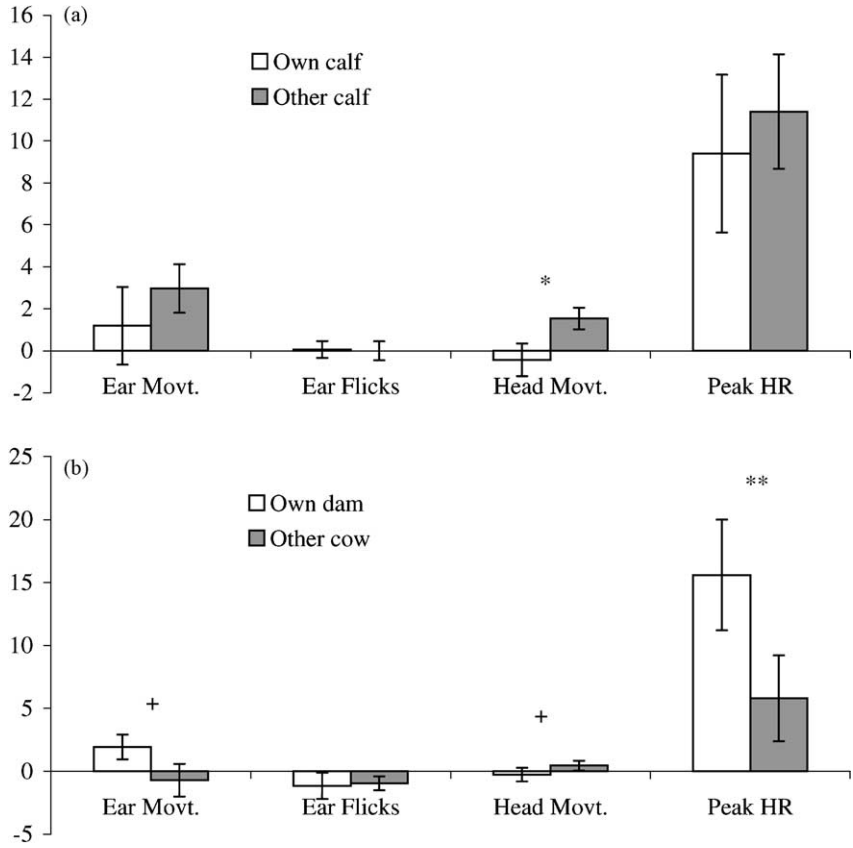


Fig. 1. Mean (± S.E.) change from pre-playback levels in number of ear movements $min^{-1}$, ear flicks $min^{-1}$, head movements $min^{-1}$ and HR (beats per minute) of (a) cows, and (b) calves, following playback of own calf/dam or other calf/cow vocalisations. ($^{**}P < 0.01$, $^{*}P < 0.1$, $^{+}P < 0.1$).

proportion of time spent lying with head raised (call $= 0.11 \pm 0.04$, noise $= -0.10 \pm 0.07$, $F_{1,22} = 5.2$, $P < 0.05$). There were no differences in the number of ear movements, orientation towards the loudspeaker or mean HRs during or after playback. The calves, however, were able to distinguish between calls of their own dam and those of another cow (Fig. 1b). Calves showed a greater peak HR change in response to calls from their dam ($F_{1,11} = 12.0$, $P < 0.01$) and tended to perform fewer head movements ($F_{1,11} = 4.2$, $P = 0.067$) but more ear movements ($F_{1,11} = 4.3$, $P = 0.063$) following playback of their own mother's calls.

## 4. Discussion

Cattle produce a variety of vocalisations (Kiley, 1972), and at least some of these are thought to be meaningful to other cattle (Watts and Stookey, 2000) and affect their

behaviour (Barfield et al., 1994). Our results show that the calls given by calves after separation from the cow elicit marked behavioural and cardiac responses from cows. A cow would typically respond to these calls by stopping any current activity, orienting toward the calls by moving her ears, head and body, and then walking toward the sound vocalising. Calves are normally silent (Hall et al., 1988), perhaps as a strategy to avoid predation, but are much more likely to call when deprived of milk (Thomas et al., 2001). Thus a response to these calls by the cow should not be considered surprising.

The cows in this study were less likely to move their heads during playback from their own calves, but otherwise showed little ability to distinguish between calls from their own other calves. Other work has failed to show recognition of calves by cows (see review by Watts and Stookey, 2000), although again, studies have been carried out primarily on dairy breeds. This limited demonstration of recognition by dairy cows is not simply due to a lack of acoustic variation; dairy calf calls are individually distinctive in duration, fundamental frequency and frequency of maximum amplitude (Thomas et al., 2001). The difficulty to demonstrate discrimination is more likely due to the fact that these calves are not highly vocal before separation (Lidfors, 1996, Weary and Chua, 2000, Flower and Weary, 2001), providing little opportunity for the cows to learn to recognize the calls from their own calf in the 24 h before separation. Studies on other ungulates have shown variable results in terms of maternal recognition of young. Red deer hinds—like the cow, a hider species in terms of mother–young relationships (Nowak, 1998)—show little ability to recognise their calves by auditory cues alone (Vankova et al., 1997). In sheep, however, ewes do appear able to respond differentially to playback of calls from their own lambs (Shillito Walser et al., 1981) and sows show greater behavioural responses to vocalisations from their own piglets (Weary et al., 1996). These apparent differences in discriminatory ability are perhaps more to do with the relative amounts of vocal behaviour performed by the neonates of each species and the different amounts of mother–offspring contact during the first few days or weeks after parturition. It might be hypothesised that breeds of cow vary in their ability to recognize calves. Beef cows, that have been selected for early calf recognition (Kiley, 1972) and are known to display higher levels of maternal care and selectivity than dairy cows (Le Neindre, 1989), may therefore show greater ability to recognise their offspring by vocal and other cues.

Cow vocalisations elicit cardiac and subtle behavioural responses in calves. Responses were greater to a calf's own dam than to calls from another cow. Calves never changed posture from lying but instead appeared to localise the sound source using head and ear movements. Subtle behavioural responses are to be expected, given the predation risks associated with any overt response by a hider species.

Barfield et al. (1994) had previously shown that 3–5 week-old calves could recognise playback calls from their own mother and would approach the loudspeaker. Red deer calves have similar ability (Vankova et al., 1997). Our results indicate that the ability of calves to distinguish individuals on the basis of auditory cues alone is present 48 h after birth and 24 h after separation. During the pre-separation period, the cow is vocal towards the calf, in some cases extremely so (Lidfors, 1996, Weary and Chua, 2000). Thus, there would be the opportunity for the calf to learn its mother's call characteristics. There is also evidence from sheep and humans that the foetus can hear maternal and other sounds in utero (Gerhardt et al., 1990, Abrams et al., 1998, 2000), thus the exposure time may be very much longer that just the period between birth and separation.

## 5. Conclusions

After separation at 24 h after calving, dairy cows responded to calf calls but showed limited ability to differentiate between calls from their own calf and calls from another calf. Dairy calves also responded to cow calls and responded more to calls from their own dam than to those from another cow. These results indicate that dairy calves are capable of individual recognition based on auditory cues at a very early age. The dairy cows' ability to recognize calls may be limited by the lack of early exposure to calls from their calves.

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