Livestock Science 128 (2010) 20–27

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

The effects of alternative weaning methods on behaviour in beef calves

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ARTICLE INFO

Article history:
Received 14 May 2009
Received in revised form 24 September 2009
Accepted 10 October 2009

Keywords:
Beef cattle
Behaviour
Calves
Weaning
Stress

ABSTRACT

The aim of this experiment was to compare the behavioural responses and weight change of beef calves weaned using three weaning methods. Forty-eight primiparous Hereford or Hereford × Angus nursing beef calves (180.7 ± 1.3 days old; mean ± SEM) were assigned to one of three treatments: 1) CON: weaned abruptly on day 0; 2) FEN: calves were separated by fence line from dams on day −17 but remained in visual sight of one another; or 3) NF: cows and calves remained together but suckling was prevented on day −17 by inserting a nose-flap anti-suckling device. In all treatments remote physical separation of the cow and calf took place on day 0. Behaviours were recorded by instantaneous sampling from day −20 to day −13, and from day −3 to day 5, except on day 0. Distance between cows and calves and the fence line in FEN calves and between the dyads in NF calves were recorded from day −17 to day −13. Body weights of calves were recorded on days −24, −11, 0, 7 and 21. There was a day and treatment by day interaction for all behaviours. Behavioural responses were strongest during the first 2 days after fence line separation in the FEN calves and after remote separation in the CON calves. For the NF calves, behavioural effects were observed immediately after insertion of the nose-flaps, including numerous unrewarded suckling events, and again when remote physical separation took place. Overall the FEN calves vocalized ($P<0.03$) more than CON and NF calves. CON calves played ($P<0.02$) and ruminated ($P<0.04$) more often than FEN and NF calves, and walked ($P=0.01$) more than NF. On day −17 and day −16, FEN calves (and their dams) spent more time within 30 m of the fence line than on day −15 to day −13 ($P<0.02$). NF calves spent more time in close proximity of their dams on day −17 and day −16 ($P<0.001$). Calves of the CON treatment had a greater average daily gain (ADG) than FEN and NF calves ($P<0.008$); ADG was greater in FEN than in NF calves ($P=0.02$). Two-stage weaning with nose-flaps resulted in a second distress response after remote physical separation from the dam, and a drop in ADG in both periods indicating that the response was distributed between the two stages. In calves weaned using the fence line method, the response was more prolonged and more intense, with no advantages for weight gain compared to abrupt weaning. In conclusion, the two alternative weaning methods did not appear to provide any clear benefits in reducing weaning distress in beef calves compared to abrupt weaning in the conditions used in this experiment. However, the use of nose-flaps seems to reduce distress better than fence line separation.

1. Introduction

Natural weaning in cattle occurs between 7 and 14 months of age, and the calf–cow dyad maintains some proximity for some months after suckling stops (Reinhardt and Reinhardt, 1981). In contrast, under management conditions, weaning in beef calves is traditionally undertaken by abruptly separating the 6–7 month old calf from its mother. At weaning, calves can experience changes in diet, new social environments, loss of maternal contact, and in many cases new housing. Not surprisingly, these changes normally result in frequent

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doi:10.1016/j.livsci.2009.10.007

displays of distress signals by calves during the first days after separation, such as vocalizations and locomotion (Newberry and Swanson, 2008). Previous work has reported that beef calves show physiological (Lefcourt and Elsasser, 1995; Hickey et al., 2003) and behavioural (Veissier and Le Neindre, 1989; Price et al., 2003; Haley et al., 2005) indicators of stress, and a drop in performance (Price et al., 2003) when abruptly weaned and separated from their dam at this age. These effects are thought to be mediated by the severance of mother–young bond (Weary et al., 2008; Newberry and Swanson, 2008) and the loss of milk supply (Ungerfeld et al., 2009).

Previous work has reported that weaning distress can be reduced by implementing pre-weaning treatments with fostered dairy calves (Loberg et al., 2008) and lambs (Schichowski et al., 2008), anti-suckling devices in beef calves (Haley et al., 2005; Siegford et al., 2007; Quintans, et al., 2008), and by fence line separation from the dam in beef calves (Stookey et al., 1997; Price et al., 2003; Siegford et al., 2007; Quintans et al., 2008; Burke et al., 2009) and wapiti calves (Haigh et al., 1997; Church and Hudson, 1999). For instance, Newberry and Swanson (2008) recommend a weaning system consisting firstly of nose-flaps followed by fence line separation, as described by Haley (2006), before remote physical separation. However, a three step procedure such as this may not be practical for many farmers. Moreover, although these alternative weaning methods have been compared with conventional abrupt weaning, to our knowledge no work has compared the behavioural response of beef calves weaned using the nose-flap device with the fence line procedure before and after remote physical separation.

Therefore, the aim of this study was to compare the behavioural response and growth rate of 6-month old calves abruptly weaned, or weaned using one of the two staged procedures: fence line separation or nose-flaps followed by final separation 17 days later. The comparison included the period immediately after implementing fence line and nose-flap treatments, and after the remote physical separation.

2. Materials and methods

2.1. Animals and management

The experiment was carried out in Palo a Pique Experimental Farm, INIA Treinta y Tres (34° S), Uruguay, between August and October (late winter–early spring 2008). Forty-eight primiparous Hereford or Hereford × Angus nursing beef calves (180.7 ± 1.3 days old; mean ± SEM; range 160 to 200 days) were used. During the experiment cows and calves grazed on native pastures.

The experiment had three treatments with two replications of eight dyads each. Four days before the beginning of each trial calves were weighed, and assigned to three homogeneous groups according to body weight, age and sex. Each group of cow–calves dyads was moved to a different paddock of 6 ha, where they remained throughout the experiment. The paddocks did not share any common fences, and were located at a minimum distance of 40 m from each other. Available dry matter per day exceeded 160 kg in all treatments.

Milk production of every dam was assessed 28 days before remote physical separation. At approximately 17:00 h cows were separated from their calves and injected intramuscular with 10 IU of oxytocin (Hipofamina® Laboratorio Dispert S.A. Uruguay). Two minutes after injection cows were milked using a portable milking machine. Calves were fitted with nose-flaps and remained with their dams in the same paddock. The following day, at 06:00 h, cows were milked again with the same protocol and the milk obtained was weighed. This procedure carried out monthly, for other studies.

2.2. Treatments

Three groups of sixteen calves were blocked by sex, age and live weight, and assigned to each of the following weaning treatments: 1) CON group: were weaned by remote physical separation from their mothers on day 0; 2) FEN group: cows and calves were separated by a fence on day −17 (but remained in visual, auditory, olfactory, and possibly tactile contact), and remotely separated on day 0; 3) NF group: cows and calves remained together but suckling was prevented by placing a nose-flap anti-suckling device (Fig. 1) on each calf on day −17, followed by remote separation (and removal of the device) on day 0. Each group was divided in two subgroups of eight to facilitate observation.

The fences separating FEN calves from cows were made of 7 strands of wire 10, 25, 40, 55, 75, 100 and 130 cm from the ground. Nose-flaps (El destete, Argentina; Fig. 1), which were similar to those described by Haley et al. (2005), were made of flexible plastic (12.5 × 12.5 cm), and prevented suckling but did not prevent grazing or drinking. At complete separation (day 0), FEN and NF calves remained in their original paddocks and the dams were removed, while CON

Fig. 1. Calf with a nose-flap.

Table 1
List of behaviours observed and their respective description.

Behaviour	Definition
Lying	Lying down in any resting position
Walking	All four legs were moving with head raised or not (still)
Grazing	Picking or consuming pasture, with the head close to the ground, still or moving slowly
Ruminating	Chewing regurgitated boluses of feed
Drinking	Mouth below the waterline in the trough ingesting water
Suckling	Teat enclosed within the calves mouth, calves acquiring milk by sucking cow's teats and deglutition signals
Suckling attempt	Non-rewarded suckling attempt: calves were observed to attempt to nuzzle the udder but did not obtain milk (because of nose-flap or cow rejection) or tries to cross its head through fence line when dam is close it
Playing	Calves were observed to be running, jumping, nuzzling objects without any apparent function
Pacing	Moving parallel to, within 1 m of, the fence line
Seeking	Beside the fence, head elevated with eyes and ears focused in the same direction (outside the paddock)
Vocalizations	Sounds made by the calf and heard by the observer

calves were moved to a 100 m^2 corral for 24 h, but then returned to their original paddock. All cows were relocated a minimum of 500 m from the calves.

2.3. Behavioural recordings

Behaviours were recorded using instantaneous sampling of individual calves in each group using 10 min scan sampling. Data were recorded 36 times day^{-1}, during three observation periods from 8:00 to 9:50, 12:00 to 13:50, and 16:00 to 17:50. During each observation day, three of four observers were assigned to different observation periods for each treatment with observers switching at the end of each observation period to block their recording between the three treatments. Recordings were carried out from day −20 to day −13, and from day −3 to day 5, except on day 0.

The behaviours observed are described in Table 1. Vocalizations were recorded for a 15 s period every 10 min using 0/1 sampling (Lehner, 1996).

2.4. Distance from fence line or dam

The distance of each FEN calf to the fence line (<5 m, 5–15 m, 15–30 m, >30 m from the fence line) was recorded at each sampling time. Distance from FEN dams to the fence line was only recorded at the beginning and the end of each sampling period (6 observations day^{-1}). Plastic rods were inserted in the ground at predetermined distances to the fence line and used to estimate distances of cow and calf to the fence line.

The distances (0–5 m, 5–10 m, or >10 m) between cow–calf pairs in the NF treatment were also recorded at each sampling. Distances were estimated using the cow's body length as a reference.

2.5. Calves' average daily gain (ADG)

Calves were weighed day −24 and day −11, on day 0, 7 and 21. ADG, which is expressed as kg day^{-1}, was calculated for each interval (−24 to −11; −11 to 0; 0 to 7 and 7 to 21).

2.6. Statistical analysis

Each behavioural event, and of calf–cow distance range are expressed as group mean (±SEM) of the percentages of the total observations per period. All data were compared with a general linear models repeated measures analysis of variance procedure (SAS, 2003), considering the treatment and day, as well as the interactions between treatment and day, as fixed effects, and the calf within group as a random effect. When significant effects or interactions were found, means were compared using *t*-tests, protected for the significance of *F*-test. Differences were considered significant at $\alpha = 0.05$.

One calf lost its nose-flap between day −13 and day −3, so all data after day −13 were removed from the experiment.

Table 2
Effect treatment, day and interactions on calf behaviour (percentage of observations ± SEM).

Behaviour	CON	FEN	NF	*P* value		
				Treatment	Day	Treatment*day
Vocalizations	1.79 ± 0.40 b	2.92 ± 0.36 a	1.33 ± 0.35 b	0.009	<0.001	<0.001
Playing	0.53 ± 0.09 a	0.17 ± 0.04 b	0.32 ± 0.07 b	<0.001	0.001	<0.001
Walking	7.89 ± 0.33 a	7.13 ± 0.31 ab	6.63 ± 0.32 b	0.04	<0.001	<0.001
Ruminating	14.69 ± 0.53 a	13.35 ± 0.48 b	12.34 ± 0.49 b	0.002	<0.001	<0.001
Suckling attempts	0.06 ± 0.03 b	0.28 ± 0.06 a	0.37 ± 0.09 a	0.007	<0.001	<0.001
Fence line pacing	0.35 ± 0.08 ab	0.38 ± 0.08 a	0.16 ± 0.08 b	0.1	<0.001	<0.001
Grazing	58.78 ± 0.88	61.24 ± 0.90	59.38 ± 1.04	Ns	<0.001	<0.001
Seeking	0.41 ± 0.08	0.58 ± 0.09	0.59 ± 0.16	Ns	<0.001	<0.001
Lying	18.93 ± 0.71	17.21 ± 0.63	17.94 ± 0.86	Ns	<0.001	<0.001
Drinking water	0.61 ± 0.08	0.62 ± 0.08	0.75 ± 0.10	Ns	<0.001	0.015

Letters indicate differences between treatments ($P < 0.05$).
Means reflect 16 calves within each group.

3. Results

3.1. Behaviours

In all recorded behaviours we observed an effect of time and an interaction between treatment and time. The frequency of calves vocalizing, playing, walking and ruminating differed between the 3 treatments, which tended to influence the frequency of fence line pacing. Main effects and *P* values are presented in Table 2.

3.1.1. Vocalizations

The frequency of vocalizations per calf is presented in Fig. 2a. The frequency of vocalizations of NF and CON calves increased from day −1 to day 1 ($P<0.001$). In FEN calves, the frequency was greater from day −17 to day −14 than on day −18 ($P<0.001$). The highest frequencies of vocalizations in FEN calves occurred on days −16 and −15 ($P<0.001$).

3.1.2. Playing

The frequency of playing decreased in FEN and NF calves after fence line separation and nose-flap insertion respectively, remaining low throughout the study. In CON calves playing frequency stopped after remote physical separation. In FEN calves playing was 0.51 ± 0.17% on days −20 and −17, and after fence line separation the behaviour was observed in two occasions in two different calves. In NF calves frequency of play was 0.72 ± 0.18% of the time on days −20 and −17, and after the nose-flaps were fitted no play behaviour was observed. In CON calves, playing frequency was 0.61 ± 0.17% on days −1 to −3, and after remote separation from the dam play behaviour was observed only once in one calf.

3.1.3. Walking

The frequency of walking is presented in Fig. 2b. Walking frequency in CON calves increased on day 1 ($P<0.001$) compared to day −1; frequencies recorded on day 2 did not differ from frequencies observed before weaning. In FEN calves walking frequency did not change after fence line or remote separation from the dam. In NF calves, the frequency of animals walking was highest on day 1, when it was different from day −1 ($P=0.002$). The frequency of walking then declined to values observed before day 1.

3.1.4. Ruminating

Ruminating frequency of CON calves was greater on day 2 (21.35 ± 1.52%; $P<0.001$) and 3 (28.47 ± 1.40%; $P<0.001$) compared to day −1 (12.85 ± 1.98%). On day 4 the frequency of rumination (16.17 ± 1.11%) decreased to values similar to those observed on day −1. In FEN calves, ruminating frequency increased ($P<0.002$) on day 1 (21.18 ± 2.79%), compared to day −1 (8.33 ± 1.72%), remaining greater on days 2 (15.45 ± 1.41%) and 3 (18.06 ± 1.56%), and thereafter decreasing to levels observed on day −1. In NF calves ruminating frequency did not change after nose-flaps insertion or after separation from the dam.

3.1.5. Suckling attempts

The frequency of suckling attempts is presented in Fig. 2c. In FEN calves frequencies of suckling attempts increased from day −17 to days −15 and −14 ($P<0.01$). On day −13 the frequency of suckling attempts declined to similar values observed on day −17. In NF calves suckling attempt frequency increased from day −18 to days −17 and −16 ($P<0.01$), returning to values similar to those recorded before the nose-flap introduction on day −15.

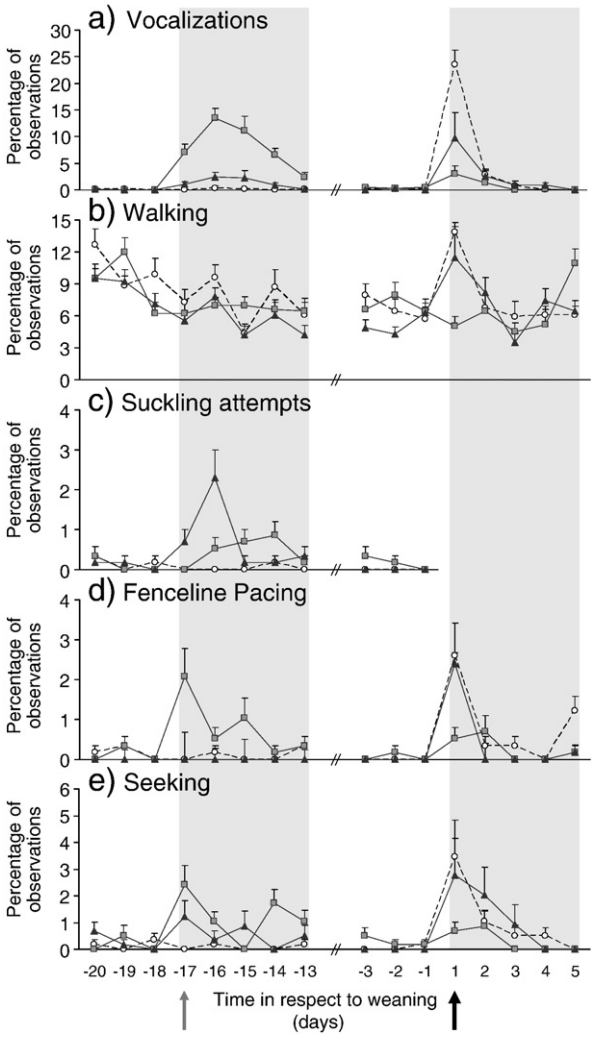

Fig. 2. Effect of separation through a fence line, nose-flap insertion and remote physical separation from dam on frequency (mean ± SEM) of a) vocalizations, b) suckling attempts, c) pacing and d) seeking ($n=16$ calves/group). Calves were abruptly separated from their mothers (CON —○—), weaned through fence line separation for 17 days (FEN —■—) or fitted with nose-flaps for 17 days (NF —▲—) before total separation from dam. Day −17 = nose-flaps inserted in NF treatment and fence line separation in FEN treatment. Day 0 = removal of cows in all treatments (no behavioural records were carried out this day). The grey thin arrow indicates introduction of nose-flaps in NF calves and fence line separation in FEN calves. The black thick arrow indicates total separation from dam.

3.1.6. Fence line pacing

Data are presented in Fig. 2d. Fence line pacing frequency increased in both CON and NF calves from day −1 to day 1 ($P<0.001$), and returned to frequencies observed before total separation on day 2. In FEN calves fence line pacing was greater on days −17 and −15 than on day −18 ($P<0.006$).

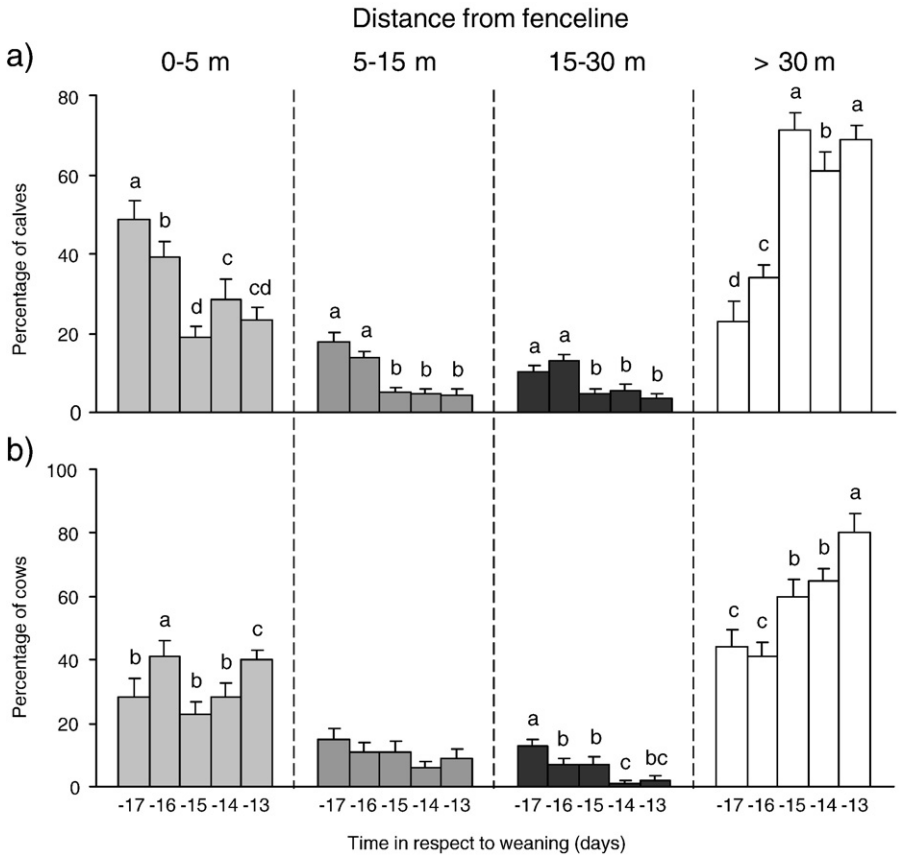

Fig. 3. Effect of separation through a fence line on percentage of a) calves and b) cows (mean ± SEM) observed at 0–5, 5–15, 15–30 or > 30 m from the fence in FEN treatment. Day −17 = day of fence line separation. Letters show differences between days ($P<0.05$).

3.1.7. Grazing

In CON calves, grazing frequency was lower on days 1, 2 and 3 (53.99 ± 2.57; 54.86 ± 3.68; 56.08 ± 1.05%, respectively; $P=0.03$) than on day −1 (64.76 ± 2.47%); thereafter, grazing returned to the frequencies observed before weaning. In FEN calves grazing did not vary throughout the duration of the study. NF calves showed a sharp drop in grazing frequency on day −17, when the nose-flaps were fitted, compared to the previous day (35.94 ± 5.24 vs. 53.13 ± 4.01% respectively; $P<0.001$), though frequencies returned to the pretreatment level on day −16 (53.60 ± 2.82%).

3.1.8. Seeking

Seeking behaviour is presented in Fig. 2e. Seeking frequency was greater on day 1 compared to days −1 in both CON and NF calves ($P<0.001$); in CON calves these returned to day −1 values on day 2, and in NF calves on day 3. In FEN calves seeking behaviour did not change on day −1 – after remote separation from the dam – but was greater on day −17 – after fence line separation – compared to day −18 ($P<0.001$).

3.1.9. Lying

Lying frequency did not change in CON calves between day −1 and 1, but increased from day 1 (19.44 ± 1.74%) to days 2 and 3 (27.78 ± 2.21 and 32.47 ± 1.52% respectively; $P<0.01$). On day 4 (21.05 ± 1.69%) lying frequency was not different from day 1. In FEN calves, lying frequency decreased two days after fence line separation (day −16 = 12.33 ± 3.39; day −15 = 10.76 ± 1.50 vs. day −18 = 20.14 ± 2.14%, $P<0.02$) and on day −14 (16.50 ± 2.59%) was no longer different to preseparation values ($P=0.3$). Lying frequency in these calves was also higher ($P<0.01$) from days 1 to 3 (27.43 ± 3.13, 19.62 ± 2.14 and 21.70 ± 2.05%, respectively) than on day −1 (11.28 ± 2.39%), returning to day −1 levels on day 4 (11.11 ± 2.03%). In the NF group, lying frequency increased from day −18 to day −17 (24.48 ± 1.97 and 43.75 ± 5.97%; $P<0.001$), but on day −16 the frequency decreased to 7.99 ± 2.39% and remained lower than day −18 until day −14 ($P<0.006$).

3.1.10. Drinking water

Drinking behaviour did not vary over the course of the study.

3.2. Distances to fence line (FEN) and between cows and calves (NF)

Distances to fence line in both calves and cows in the FEN treatment increased gradually between days −17 and −13. Calf–fence line distances were affected by day ($P<0.001$; Fig. 3a). On the first day after fence line separation approximately 50% of the calves were observed between 0 and 5 m from the fence ($P=0.04$); the distance from the fence changed gradually: three days after fence line separation more than 70% of the calves were observed farther than 30 m.

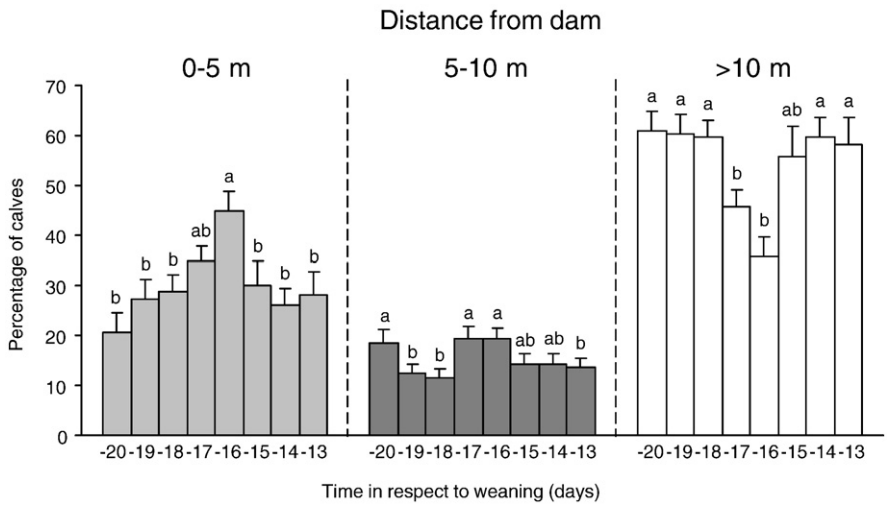

Fig. 4. Percentage of calves at 0–5, 5–10 or > 10 m from the dam (mean ± SEM) in NF treatment. Day −17 = nose-flaps inserted in calves. Letters show differences between days ($P<0.05$).

Except for the range 5–15 m, all the distance ranges of cow–fence line distance were affected by day ($P<0.001$; Fig. 3b). On the first two days after fence line separation approximately 45% of the cows were observed at > 30 m from the fence ($P=0.02$), and this percentage increased gradually from days −16 to −13.

The distance of NF calves to their dams changed after inserting the nose-flaps ($P<0.03$; Fig. 4). Calves were found closer to their dams during the first two days following nose-flap introduction compared to previous days ($P<0.001$), returning to the values observed before nose-flap introduction after the third day.

3.3. Cows' milk production

Cow's milk production did not differ between treatments, and was estimated at 2.2 ± 0.26 L/day.

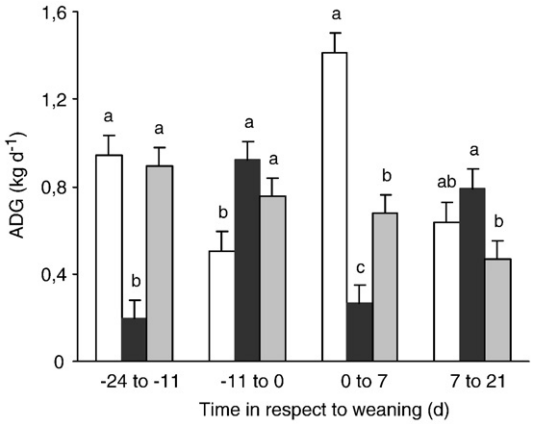

Fig. 5. ADG changes (mean ± SEM) in calves ($n=16$/treatment) abruptly weaned (CON — white) separated by a fence line from their mothers 17 days before weaning (FEN — grey), or fitted with a nose-flap 17 days before weaning (NF — black). In all treatments total separation from the dam was performed on day 0. Treatments with different letters differed within periods ($P<0.05$).

3.4. Average daily gain

There were effects of treatments ($P<0.001$) and an interaction between treatment and day ($P<0.001$) on ADG (Fig. 5). CON calves had a greater ADG than FEN and NF calves ($P<0.008$); ADG in FEN calves was greater than in NF calves ($P=0.02$).

4. Discussion

Abruptly weaned CON calves responded to separation by increasing vocalizations, pacing, walking, seeking behaviour and lying for one to two days and reducing play behaviour for the rest of the observation period. Distress behaviours such as vocalizing and pacing had the greatest peaks after weaning in CON calves. The FEN and NF calves displayed similar responses, but also attempted numerous unsuccessful suckling events immediately following the fence line and nose-flap introductions, respectively. Despite the fact that the suckling events were unsuccessful they were numerous during the first three days of treatment, particularly in the case of the NF calves. This behaviour resembles others that have been cited as evidence of frustration (Latham and Mason, 2008) and provides the first evidence that these alternative weaning methods should be viewed with some caution. Although previous work has implied that these two alternative weaning methods result in a reduction in overall distress behaviours associated with weaning in beef calves (Price et al., 2003; Haley et al., 2005; Quintans et al., 2008), our data suggest that there is no overall reduction but rather a redistribution over two periods. Factors such as the duration of the nose-flap treatment (Haley et al., 2005), cow's milk production and developmental stage of the calves (Ungerfeld et al., 2009), climate (Pollard and Littlejohn, 2000), type of fence and weaning age might influence the calves' responses to weaning and explain some of the differences noted between our work and previous research in this area. We suggest that further research involving methods aiming at reducing the distress of calves at weaning should consider those conditions.

The concurrent reduction in the distance between the calf–dam pair at the time we observed the increase in suckling attempts by the NF calves provides further evidence that the calves were experiencing some distress. An increase in closeness in the calf–cow dyad after nose-flaps were inserted was also reported by Haley et al. (2005). Behaviours such as vocalizing, walking and seeking were not observed, which may be related to the availability of the direct contact with the dam, as they possibly reflect attempts to reunite with the dam. Nonetheless, this does not mean that inability to suckle comes at no emotional cost to the calves. Furthermore, the drop in ADG and lack of any play behaviour following the use of the nose-flaps provide evidence suggesting a negative effect on the emotional state of these calves. Also, if both milk and thermo-tactile stimuli are involved in the mediation of affiliative behaviours in the young mammal (Nelson and Panksepp, 1998), the physical closeness with the dam may reflect a need to adjust to physiological changes associated with the sudden loss of milk. Other studies also suggest that there might be a transient period of distress associated to the prevention of suckling in young mammals. When fitted with nose-flaps and kept with the cows, beef calves walked more than control, non-weaned calves (present results; Haley et al., 2005). Furthermore, 10-week old fostered dairy calves fitted with nose-flaps and left with the nurse cow showed a reduction in social behaviours compared to calves that were weaned by abrupt separation from the dam (Loberg et al., 2008). Similarly, increased cortisol and differential responses to social challenges were observed in early-weaned lambs reared with the ewe but prevented from suckling (Napolitano et al., 2003). Therefore, the behavioural pattern of NF calves should be interpreted with caution, and the possibility of emotional distress associated with the prevention of suckling should not be discarded.

In the FEN treatment, the dams spent almost half of the time at a distance greater than 30 m from the fence line on the first day after separation. However, during that time the calves showed important signals of distress, with an increase of vocalizations, pacing, and suckling attempts, and an abrupt stop of playing behaviour. A gradual reduction in the proportion of time the calves spent close to the fence during the first two days after fence line separation was observed and, from the third day on, they spent 70% of the time more than 30 m away from the fence. A similar trend for a reduction in the time the calves spent close to the fence was observed by Price et al. (2003). Our results are also in agreement with a study investigating weaning in lambs where it was suggested that by the third day after separation the maternal bond becomes weaker (Galeana et al., 2007).

Although the pattern of spatial distribution suggests a rapid adaptation of calves to separation from their mothers, our behavioural data suggest that a strong and prolonged response did take place. During the first two to three days after fence line separation, FEN calves spent up to 65% of the time very close to the fence separating them from their dams, pacing and displaying reinstatement behaviours such as seeking and vocalizing. Although the highest rates of these behaviours occurred during the first two days after fence line separation, the response continued until the end of the first observation period, on day −13. Additionally, during the first three days after separation the visual presence of the dam appeared to act as a stimulant encouraging calves to attempt to suck through the fence. Thus, because these suckling attempts were unrewarded the fence line contact with the dam may inadvertently have been a source of frustration. Previous work suggests that being physically separated while maintaining visual, auditive or olfactory contact with their dam (as in the case of the FEN calves) may be a major source of distress for the young. Temporal separation of zebu beef calves with fence line contact produced increased distress behaviours compared to remote physical separation in beef calves (Solano et al., 2007). Weaned red deer calves kept within visual and auditory contact from the dams showed a prolonged distress response compared to calves that were moved to a different farm (Pollard and Littlejohn, 2000). Dairy calves had a more intense and longer seeking response to separation during the first days after birth if visual and auditory contact with their dams was maintained (Stěhulová et al., 2008). Our work indicates that fence line separation may in fact increase the level of frustration in calves, due to the perceived potential for physical contact with the dam and access to the udder.

In order to develop methods that reduce weaning distress in farm animals, it is necessary to understand how the different factors involved in weaning contribute to weaning distress (Weary et al., 2008). After abrupt weaning at 6 months of age, calves reared by cows that produced more milk displayed more behaviours indicative of distress than calves reared by lower producing cows, suggesting that the loss of milk contributes to the distress response at weaning in beef calves (Ungerfeld et al., 2009). In the present study an increase in vocalizations, seeking and pacing and a loss in ADG were observed after NF calves were permanently separated from the cow, indicating distress. These responses were independent from the loss of milk supply, which had occurred two weeks prior, indicating that the loss of the dam *per se* contributes, in part, to the emotional distress of weaning in calves.

In conclusion, we found no clear benefits for the calves in either of the two alternative weaning methods studied, compared to abrupt weaning. Although not as marked as after abrupt weaning, two-stage weaning with nose-flaps resulted in behavioural changes after the installation of the device and again after total separation from the dam. Worrisome for the producer is the drop in ADG in both periods, suggesting that, rather than reducing the distress response this alternative weaning practice distributed the distress response between the two stages. Thus, it is difficult to judge the outcome for the calves of this treatment in terms of animal welfare. In calves submitted to fence line weaning the response was more prolonged and appeared to be more intense, with no advantages for weight gain compared to abrupt weaning.

Acknowledgements

We acknowledge Janaína Hammerschmidt, Alicia Félix and Zully Ramos for help with behavioural recordings, and Juan Luis Acosta, Gustavo Pereira, and Ignacio Velazco who helped with animal management. We are grateful to Marina von Keyserlingk and Naomi Latham for comments on an

earlier draft of this manuscript. DEH was sponsored by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil. RU visited UFSC supported by the UFSC Postgraduate Programme in Agroecosystems.

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