The effects of weaning beef calves in two stages on their behavior and growth rate

D. B. Haley*[1], D. W. Bailey†[2], and J. M. Stookey*

*Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon S7N 5B4, Canada; and
†Northern Agricultural Research Center, Montana State University, Havre 59501

ABSTRACT: Four trials were conducted to explore possible advantages of weaning beef calves in two stages compared with the traditional method of weaning by abrupt separation. In the two-stage treatment, calves were prevented from nursing their dam for a period (Stage 1) before their separation (Stage 2). Control calves nursed from their dams until they were separated. Calf weights and behavior were recorded before and after the separation of cows and calves. Following separation, calves weaned in two stages vocalized 96.6% less ($P = 0.001$) and spent 78.9% less time walking ($P = 0.001$), 23.0% more time eating ($P = 0.001$), and 24.1% more time resting ($P = 0.001$) than control calves. Compared with controls, two-stage calves had lower ($P < 0.001$) ADG when nursing was deprived (Stage 1), but greater ($P < 0.001$) ADG during the 7 d following separation. In Trial 3, calves weaned by the two-stage method had greater ($P = 0.05$) growth rates than control calves for 7 wk after separation, but no treatment effects on ADG were detected ($P > 0.38$) in Trials 1 and 2. Over the entire study period (before and after separation), ADG did not differ ($P > 0.10$) for both treatments. In Trial 4, calves weaned in two stages walked 1.3 km/d more ($P < 0.05$) during the 4-d period when nursing was prevented (Stage 1) and 5.8 km/d less ($P < 0.05$) during the 4-d period after separation than controls. Differences between treatments were the greatest in the 2 d after separation. On the first day after separation, two-stage calves walked 5.2 ± 0.5 km/d, whereas control calves walked 16.7 ± 3.1 km/d. Calves weaned in two stages were less distressed than calves weaned by the traditional method of abrupt separation based on behavioral data, but overall calf ADG did not differ for either method in this study. Nutritional management of two-stage weaned calves during the nursing-deprived period should be evaluated in future research because poor pasture conditions may have decreased gains by calves weaned by the two-stage method in this study.

Key Words: Beef Cattle, Behavior, Calves, Growth, Weaning

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Introduction

Most beef cattle are weaned by the abrupt separation of cows and calves. Behavioral responses to this event are predictable and remain detectable for several days after separation. Cows and calves vocalize repeatedly and spend more time walking, while spending less time eating and resting (Veissier and le Neindre, 1989). These deviations from normal behavior provide evidence that the traditional method of weaning by separation has a negative effect on the well-being of beef cattle.

Although often recommended (e.g., Neumann, 1977), separating cows and calves by the greatest distance possible does not diminish their response to traditional weaning. In contrast, providing fence-line contact for cows and calves by separating them into adjacent pens or pastures, where they can see and hear one another, decreases vocalizing and time spent walking, increases time spent eating (Stookey et al., 1997), and increases calf ADG (Price et al., 2003).

Recently, a new method of weaning cattle in two stages has been discovered, which may decrease behavioral disruption to calves more than providing fence-line contact (Haley et al., 2001). Preventing nursing between cow-calf pairs (Stage 1) before separation of the mother and young (Stage 2) seems to decrease the degree of behavioral changes compared with imposing both restrictions simultaneously.

[1]Current address: Alberta Agric. Food and Rural Development, 301-4920 50th St., Red Deer, Alberta T4J 1M6, Canada.

[2]Correspondence (and current address): Dept. Anim. and Range Sci., Box 30003 MSC 3-I, New Mexico State Univ., Las Cruces 88003-0003 (phone: 505-646-2554; fax: 505-646-5441; e-mail: dwbailey@nmsu.edu).

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Our objective was to further contrast behavioral responses of calves weaned in two stages and calves weaned by abrupt separation and to explore possible performance benefits by assessing the ADG of calves weaned using these two methods. In one of four trials, we also evaluated two-stage weaning when nursing was prevented for long (14 d) and short (3 d) periods. Calves are often vaccinated at least 2 wk before weaning to decrease the possibility of respiratory diseases (Pritchard and Mendez, 1990). To minimize handling, the two-stage procedure could be initiated by fitting calves with nose-flaps when they are vaccinated before weaning.

Materials and Methods

General

In accordance with the Canadian Council on Animal Care Guidelines for the Use of Animals in Research, experimental procedures used in the trials described herein were approved by the Committee on Animal Care and Supply at the University of Saskatchewan (UCACS Protocol No. 20000096) and by the Institutional Animal Care and Use Committee at Montana State University (IACUC Protocol No.1055).

In all four trials of this study, two-stage weaning was compared with a control, which was the traditional weaning practice of abruptly separating calves from their mothers without other management. Calves weaned in two stages were prevented from nursing their dams for a period (Stage 1) before separation (Stage 2). Nursing was prevented by fitting calves with an antisucking device made of flexible plastic (Villa Nueva S.A., Villa Maria-Cordoba, Argentina; Figure 1). The nose-flap device (12.0 cm × 7.5 cm) acted as a physical barrier, which prevented calves from getting a teat into their mouth, but did not interfere with grazing, eating, or drinking. Control pairs nursed until they were separated. After separation, cows and calves from all treatments were completely isolated from each other, prohibiting visual contact or vocal communication.

Trial 1

In this trial, two-stage calves were fitted with the antisucking device for 14 d (long two-stage treatment; n = 58) or 3 d (short two-stage treatment; n = 58) before separation, and compared with control calves (n = 74). In total, 190 cow-calf pairs were used in the study, but only 116 antisucking devices were available. Cows and their calves were assigned randomly to treatment groups.

This trial was conducted at Montana State University's Northern Agricultural Research Center in Havre. All cow-calf pairs grazed a 421-ha native rangeland pasture dominated by rough fescue (*Festuca scabrella* Torr.) and Kentucky bluegrass (*Poa pratenis* L.) before separation, with mineral supplement (American Stock-

A

B

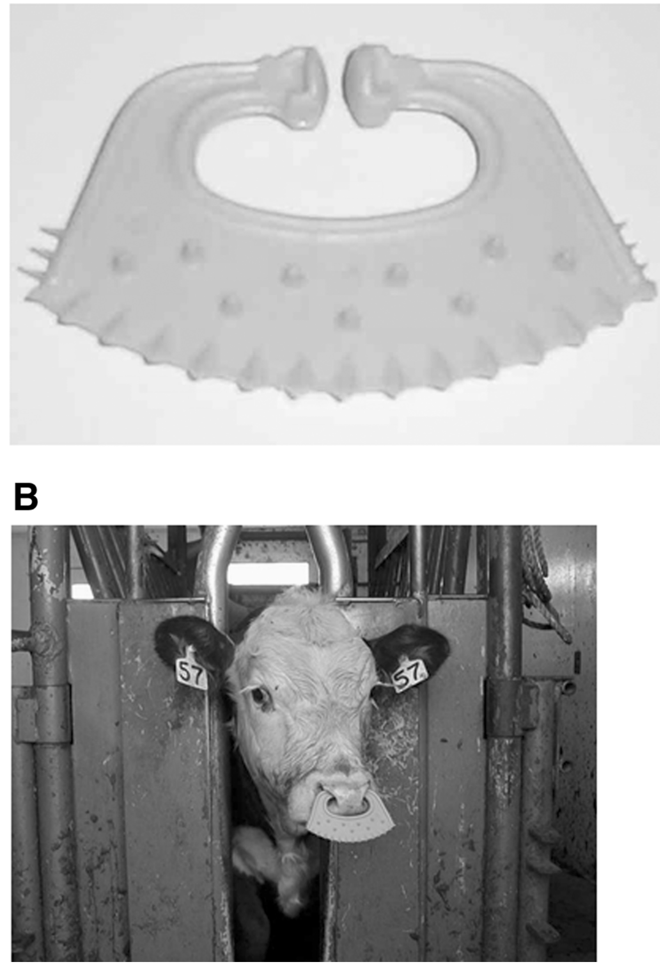

Figure 1. Photograph of the plastic antisucking device (nose-flap) worn by calves weaned in two stages (A). The nose-flap prevents nursing by providing a physical barrier between the calf's mouth and the cow's teat. Photograph of a calf fitted with the antisucking device (B).

man Big 6 Trace Mineral Salt, North American Salt Co., Overland Park, KS) and water available ad libitum. On the day of separation, the mean (±SD) age of calves was 187 ± 13 d (range = 159 to 209 d).

Behavior. Previous anecdotal observations suggested that when nursing is prevented between two-stage pairs, that the cow and calf may spend their time in closer physical proximity to one another compared with pairs still able to nurse. We tested this on foothill rangeland on the 2 d immediately before the separation of cows and calves. Starting at sunrise (0630), cattle were observed within the 421-ha pasture by three observers on horseback. The purpose of the observations was to attempt a scan sample of the 190 cow-calf pairs in the pasture. During the 1.5-h/d observation periods, we encountered and recorded data for 56% of the animals. The percentages of animals observed from each treatment group were approximately equal (long two-stage = 57%, short two-stage = 59%, and control = 53%). Binoculars allowed animals to be identified at a distance by their ear tag numbers. Observers used herd lists to identify cow-calf pairs. After noting the time and confirming ear tag numbers, the distance between the cow and its calf was estimated and scored using two categories: nearby (≤10 m) and distant (>10 m).

Nose-flaps were removed from two-stage calves on the day pairs were separated, and all calves were weighed and then transported by truck for approximately 1 h to another farm, where they were unloaded and left overnight. The following morning, balancing for equal numbers of males and females, 30 randomly selected calves from each treatment were removed from the larger group and put in experimental drylot pens (5 m × 10 m, with 5 m of feeding space). A total of 15 pens was used, each containing six calves (five pens per treatment). Each pen had smooth brome (*Bromus inermis* Leyss.) grass hay and water available ad libitum. Remaining calves were housed together in two adjoined corrals (30 × 45 m, with 25 m of feeding space), but away from the experimental pens.

Observations of calf behavior in the experimental pens started roughly 24 h after pairs had been separated. Calves were observed for 8 h (from 1100 to 1900) on the first day of observation, and on the following day (the third day of separation), calves were observed for 12 h (from 0700 to 1900).

Instantaneous sampling was used at 10-min intervals to record the number of calves in each pen that were lying, standing, walking, eating, and ruminating. Activities were not all mutually exclusive. For 2 min during each interval, we counted the total number of vocalizations coming from each of three pens (one pen per treatment). All pens also were sampled an equal number of times for vocalizations, on a rotating basis (three pens per 10-min interval). Any audible vocal sound that could be attributed to a specific calf was counted as a vocalization. To avoid any potential bias, observers were blind to the assignment of treatments to pens.

Growth Rate. All calves in this study were weighed 14 and 3 d before separation, which corresponded to when calves from the two-stage treatment groups were fitted with nose-flaps. Calves also were weighed on the day of separation and then 8, 23, and 44 d later. For 4 d after separation, calves were kept in the pens described above and fed smooth brome grass hay. All calves were then moved to a pasture that had been previously hayed. Calves grazed on the regrowth, primarily smooth brome and Kentucky bluegrass, during the period from 5 to 44 d following separation.

Trials 2 and 3

Two additional trials were completed to compare the growth rates of calves weaned in two stages to control calves. In both trials, two-stage calves were deprived of nursing for 5 d before separation.

Trial 2 was conducted at the Western Beef Development Centre, Termuende Research Farm, Lanigan, Saskatchewan, Canada. A total of 100 calves aged 189 ± 10 d (range = 158 to 214 d) at separation were weaned for this trial (two-stage, n = 50; control, n = 50). Calves were assigned randomly to treatment, with an equal number of females and castrated males in each treatment. After separation, calves were grouped as a pen of heifers and a pen of steers. Thus, both treatment groups were managed under the same environmental conditions and feeding regimens.

Trial 3 was carried out at the University of Saskatchewan, Goodale Research Farm, Floral, Saskatchewan, Canada. A total of 52 heifer calves was weaned (two-stage, n = 26; control, n = 26). At separation, calves averaged 181 ± 13.7 d of age (range = 137 to 201 d). Following separation, an equal number of calves from each treatment were assigned randomly to one of two pens (30.5 m × 27.5 m).

Growth Rate. All calves in Trials 2 and 3 were weighed 5 d before separation, when the two-stage calves were fitted with nose-flaps. Calves were then weighed on the day of separation, and 7, 28, and 56 d after separation.

Trial 4

The final trial of this series was carried out at a farm near Delisle, Saskatchewan, Canada, to investigate a methodology for quantifying the walking behavior of calves at weaning time. Fifty cow-calf pairs were weaned, with an equal number of subjects assigned randomly to two-stage and control treatments. Nursing by two-stage pairs was prevented for 4 d before separation. Pairs were kept in a 20-ha rangeland pasture dominated by little bluestem [*Schizachyrium scoparium* (Michx.) Nash], crested wheatgrass [*Agropyron desertorum* (Fisch. Ex Link) Schult.], and alfalfa (*Medicago sativa* L.) before separation. Following separation, the 50 calves were housed together in a drylot pen measuring 27.4 × 48.8 m, with water and smooth brome and alfalfa hay available ad libitum.

Behavior. A subset of five randomly selected calves from each treatment group wore a pedometer, which was securely housed in a protective plastic casing and attached to the calf's front left leg with a Velcro strap (HJ-104, Omron Healthcare, Inc., Vernon Hills, IL; Figure 2). To collect baseline information about walking behavior, the pedometers were attached 3 d before preventing two-stage calves from nursing. Pedometers also recorded the number of steps taken during the 4 d that two-stage calves were prevented from nursing, and for 4 d following the separation of cows and calves. The HJ-104 model featured a 7-d memory, which logged the number of steps taken by 24-h periods. The pedometers were designed for human use and, although not validated for use on cattle, precautionary measures were taken to ensure pedometers stayed in a vertical position while attached to the calves' legs, in a manner similar to their intended use in humans. Each time calves were

A

B

Figure 2. Photograph showing a pedometer and protective casing that was used in Trial 4 to continuously record the number of steps taken (A). Photograph of casing strapped to the leg of a calf (B).

handled, the number of steps recorded by the pedometers was noted and the devices were then reset.

Statistical Analyses

Trial 1. Data collected on the proximity of cows to their calves were first examined to ensure that values for individual cows were not recorded more than once on any given day. In cases of duplicate observations of the same cow-calf pair during an observation period, only the earliest observation from that day was used for analysis. Data were analyzed by using χ^2 contingency tables (Lehner, 1996). Separate 2×3 contingency tables (proximity category $\times$ treatment) were completed for each day of observation, so that the analyses did not include repeated measures.

All 20 h of calf behavior data observed in the experimental pens were analyzed together. Total frequency counts for each behavior variable were tallied for each pen, as were the total number of individual calf observations (calves in each pen $\times$ total number of intervals observed). All data were analyzed using a generalized estimating equations (**GEE**) method to account for repeated measures within pen using PROC GENMOD of SAS (SAS Inst., Inc., Cary, NC). Model specifications included a binomial distribution, logit link function, repeated statement with the subject equal to pen number, and an AR(1) (autoregressive) correlation structure. Variables remaining in the final multivariable model at $P < 0.05$, based on the robust empirical standard errors produced by the GEE analysis, were considered statistically significant. Because vocalizations were recorded as count data, they were analyzed with a Poisson distribution and log link function.

For the purpose of visualizing these data, results are presented as the percentage of observations (percentage of the 20-h observed time) that individual animals spent performing each activity. Vocalizations are presented as the number of calls per hour for each calf, which was estimated for individuals within each pen based on results from the interval sampling of that pen by the methods described previously.

Based on ANOVA, the initial calf BW in Trial 1 collected before experimental manipulations did not differ ($P > 0.10$) among the three treatment groups. The growth rate (ADG) of calves from all three weaning treatments was then compared during the 14 d before separation, during the first 7, 23, and 44 d after separation, and finally over the entire 58-d period from 14 d before to 44 d after the separation of cows and calves. In addition, we compared calf ADG from the time nursing ended (d 0 for controls, d –3 for short two-stage weaning and d –14 for long two-stage weaning) until the end of the study (d 44). Analysis of ADG during each period of interest was performed separately using PROC GLM of SAS, incorporating treatment, sex, and age of the calf as main factors in the final model. Interactions were evaluated, but they were not significant ($P > 0.10$) and were excluded from the final model. Single degree of freedom orthogonal contrasts were used to compare the two-stage treatments to controls and to compare the two-stage treatments to each other.

Trials 2 and 3. Growth rates from Trial 2 and Trial 3 were analyzed in the same way as in Trial 1. Average daily gain was compared during the 5 d before separation (the period when two-stage calves were prevented from nursing), during the first 7 and 28 d after separation, and then over the entire 33-d period from installation of the nose-flaps to 28 d after cows and calves were separated. We also compared ADG from the time that nursing ended (d –5 for two-stage calves, d 0 for controls) until the end of the study (d 28). The model used to evaluate ADG in Trial 2 included treatment, sex, and calf age. Sex was not included in Trial 3 because only heifers were used. Data from Trials 2 and 3 were combined and analyzed with a model containing study site (Termuende and Goodale), calf age, and weaning treatment (two-stage and control).

Trial 4. The number of steps taken by calves was analyzed for four distinct time periods: 1) the baseline period (3 d) when all pairs were nursing; 2) the 4 d before separation (two-stage calves prevented from nursing); 3) the 4 d after separation; and 4) the 8-d period from placement of the nose-flaps until 4 d after separation. Steps were analyzed using the GEE method of SAS to account for repeated measures taken on the same calf. Model specifications included a normal distribution, identity link function, repeated statement with the subject equal to calf, and an AR(1) correlation structure. Variables remaining in the final multivariable model at the $P < 0.05$ level, based on the robust empirical standard errors produced by the GEE analysis, were considered statistically significant.

The effects of treatment and day on the number of steps walked by calves were analyzed during the same four time periods listed above. Associations between both day and treatment for the number of steps taken were first examined alone. When both of these factors were significant, treatment and day were examined together with the treatment × day interaction term. If the interaction term was significant, treatment effects were examined on individual days. The control group was always used as the reference group.

Results

Trial 1

Behavior. During the 2 d before separation, the proportion of calves less than 10 m from their mothers and the proportion of calves greater than 10 m from their mothers differed ($P < 0.001$) among the three treatment groups. Results were similar on both days of observation (Figure 3). Calves from the short two-stage weaning treatment (calves most recently prevented from nursing) were found in closer proximity to their mothers than calves from the other two treatment groups.

Observations of calf behavior on d 2 and 3 after separation revealed that control calves produced 41.9 calls/h, which was approximately 20 times more than the average of calves weaned in two stages (1.4 calls/h; $P < 0.001$; Figure 4). There were no treatment differences in calling behavior ($P > 0.48$) of calves separated after 14 d without nursing and those separated after 3 d without nursing. Call rates for both long and short two-stage groups were low (1.7 and 1.1 calls/h, respectively). During the 20 h observed, calves weaned in two stages also spent less time walking (14-d two stage = 34.8 min; 3-d two stage = 26.9 min) compared with control calves (146.3 min; $P < 0.001$; Figure 4). Two-stage calves spent more time lying down after separation ($P < 0.001$). Whereas control calves lay on average for 12.8 h of the 20 h observed, long and short two-stage calves lay for an additional 3.6 and 2.6 h, respectively. Two-stage calves also spent more time eating than the control calves ($P < 0.001$). During the 20 h observed, control calves spent 9.8 h eating, whereas calves from the long and short two-stage groups spent 12.4 and 11.8 h eating, respectively, which was approximately a 23% more time spent eating for calves weaned in two stages.

Regarding differences between the two-stage weaning treatments after separation, calves prevented from nursing for longer (14 d) periods spent more time walking (an additional 4.0 min over 20 h observation; $P < 0.01$; Figure 4) and more time lying (an additional 31.8 min over 20 h of observation; $P < 0.05$; Figure 4) than two-stage calves prevented from nursing for 3 d.

Growth Rate. During the 14 d before separation, the ADG by nursing control calves was greater ($P < 0.001$) than by calves in either of the groups that were prevented from nursing for at least some portion of that time (Figure 5). Calves prevented from nursing for 3 d had a greater ADG ($P < 0.001$) than those calves prevented from nursing for the full 14 d period (d −14 to d 0). During the first 8 d following separation, however, calves from both two-stage treatment groups gained more weight ($P < 0.001$) than control calves (Figure 5). Furthermore, short two-stage calves gained more weight than calves in the long two-stage group ($P <$

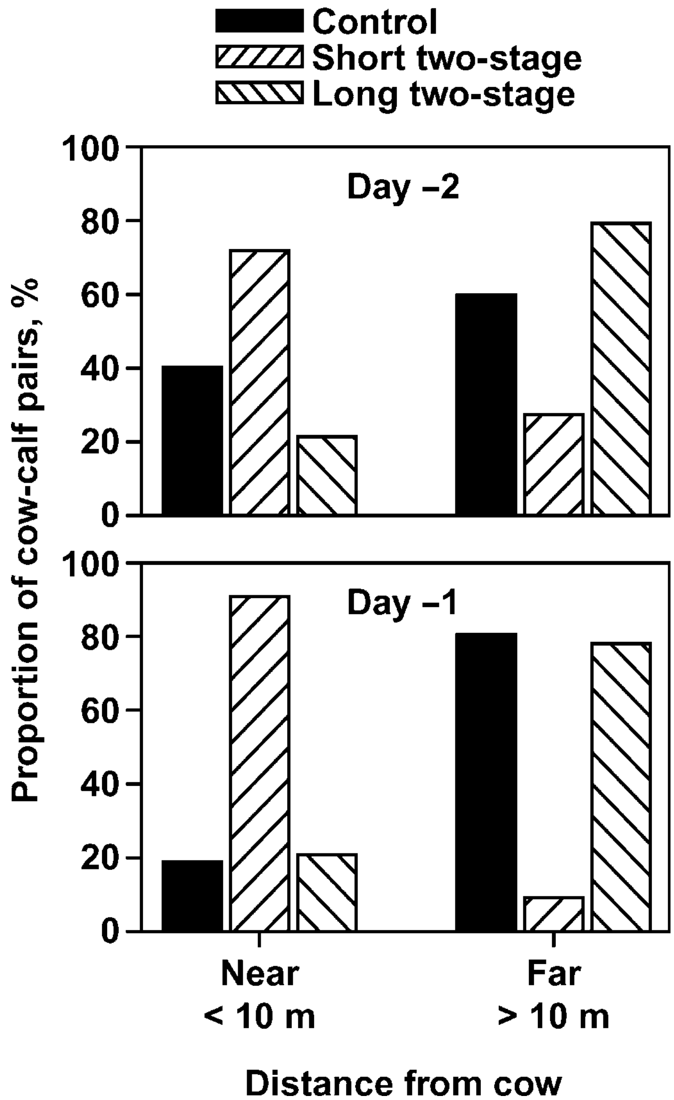

Figure 3. Proportion of calves that were observed near their mother (≤10 m) and distant from their mother (>10 m) for cow-calf pairs in the long two-stage (nose-flaps on calves for 14 d before separation), short two-stage (nose-flaps on calves for 3 d before separation), and control (traditional weaning by separation) treatment groups. Data were recorded during morning observations on the 2 d before separating calves from their dams. On d −2 and d −1, values differed ($P < 0.001$) from values expected by chance ($\chi^2 = 18.6$, 2 df, n = 111; $\chi^2 = 44.0$, 2 df, n = 97; for d −2 and d −1, respectively).

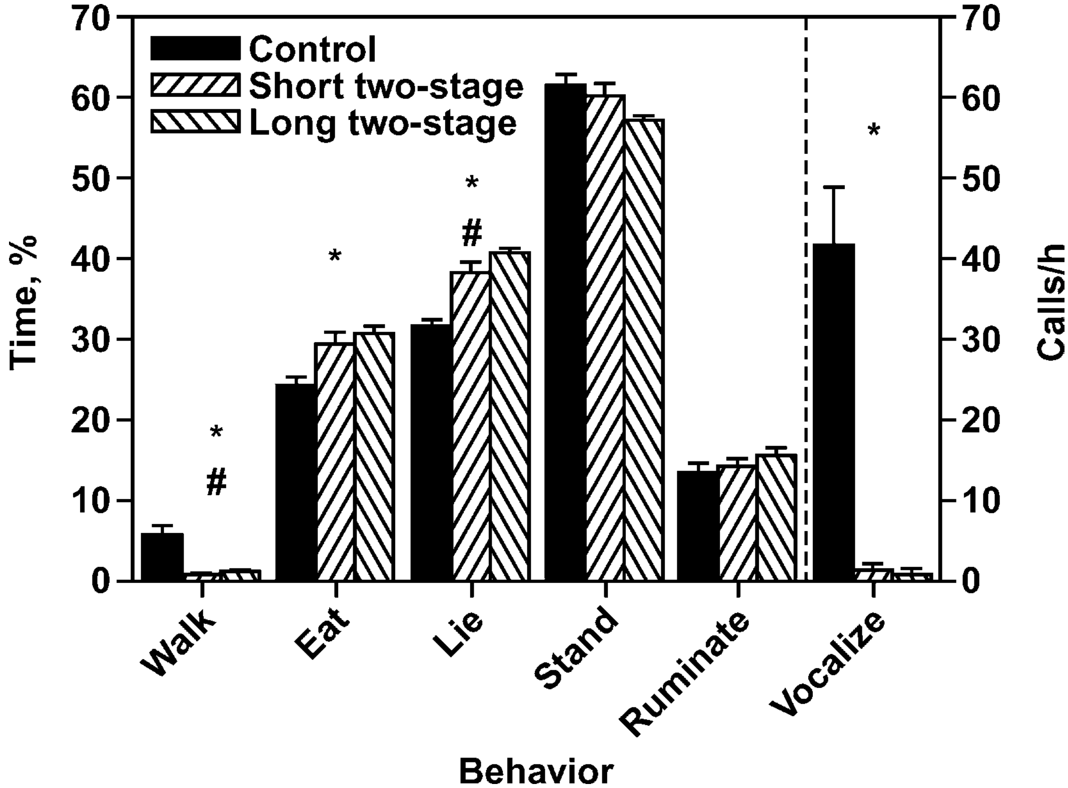

Figure 4. Effect of three weaning procedures on the percentage of time (mean ± SD) calves spent performing each behavior during the second and third day after calf removal from their dams in Trial 1. Calves were either weaned in two stages or by the traditional method of separation (control). Calves in the two-stage weaning treatments were fitted with a nose-flap, anti-sucking device that prevented nursing. Nose-flaps were applied for 14 d (long two-stage; n = 30) or 3 d (short two-stage; n = 30) before the removal of calves from their dams. The control treatment (n = 30) used the traditional approach of removing calves from their dam without prior prevention of nursing. Bars with an asterisk differed between two-stage weaning treatments (long and short two-stage treatments pooled) and controls, $P < 0.05$. Bars with a pound sign differed between the long and short two-stage weaning treatments, $P < 0.05$.

0.001) during that first week after separation. The d-0 to d-44 gain by calves weaned in two stages did not differ ($P > 0.10$) from that by control calves; however, the long two-stage calves gained less weight ($P < 0.01$) than calves in the short two-stage group during this period. Over the entire trial (d –14 to d 44), control calves had greater ($P < 0.001$) ADG than calves weaned in two stages, and ADG by short two-stage weaned calves was greater ($P < 0.001$) than the long two-stage treatment. In a comparison from the end of nursing to the end of the study period, the ADG of long two-stage calves (0.31 ± 0.02 kg/d) was less ($P < 0.001$) than the other two treatments, but there was no difference ($P = 0.09$) in ADG between the short two-stage calves (0.39 ± 0.02 kg/d) and controls (0.43 ± 0.02 kg/d).

Trials 2 and 3

In Trial 2, during the period when two-stage calves were prevented from nursing, ADG by two-stage calves did not differ from that by calves that were nursing ($P = 0.86$; Table 1). In contrast, ADG by two-stage calves during the period when they were prevented from nursing in Trial 3 was less than the ADG by control calves ($P = 0.003$). During the first week after separation, however, two-stage calves gained 0.42 kg/d more ($P = 0.001$) than the control calves, when Trials 2 and 3 were combined (Table 1). When evaluated over the 28-d period after separation, ADG did not differ ($P = 0.67$) between weaning treatments in Trial 2, but in Trial 3, ADG was greater ($P = 0.03$) by calves weaned in two stages than by control calves. When the entire study period was considered (d –5 to d 28), ADG was not affected ($P > 0.10$) by the weaning treatments in either trial or when data from Trial 2 and 3 were pooled and analyzed together. Comparing ADG from the end of nursing until the end of the study, two-stage calves (0.88 ± 0.08 kg/d) had a greater ADG ($P = 0.03$) than control calves (0.78 ± 0.08 kg/d) in Trial 3, but ADG did not differ between treatments in Trial 2 ($P = 0.84$).

Trial 4

There were no treatment differences ($P = 0.38$) in the number of steps taken by calves when all pairs were nursing (Figure 6). During the 4-d period when two-

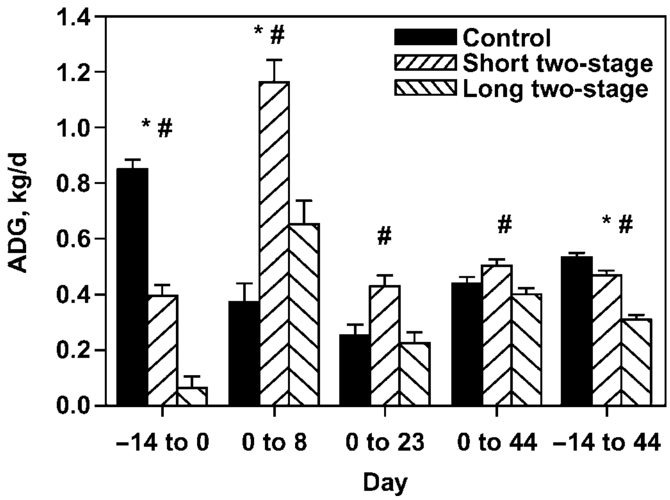

Figure 5. Least squares means (±SE) for ADG by calves in Trial 1 that were weaned in two stages or weaned by the traditional method of separation (control). Two-stage treatment calves were prevented from nursing by placing a nose-flap, antisucking device, for 14 d (long two-stage; n = 57), or 3 d (short two-stage; n = 58). The control treatment (n = 73) used the traditional approach of removing calves from their dam without prior prevention of nursing. Data are presented for: 14 d before separation (d –14 to 0); the first 8 d following separation (d 0 to 8); 23 d following separation (d 0 to 23); 44 d following separation (d 0 to 44); and from 14 d before separation until 44 d after separation (d –14 to 44). Bars with an asterisk differed between controls and two-stage treatments (long and short two-stage treatments pooled), $P < 0.05$. Bars with a pound sign differed between the long and short two-stage treatments, $P < 0.05$.

stage calves were prevented from nursing, they took on average 2,019 more steps/d than their nursing counterparts ($P < 0.05$). Applying a standard calf stride length of 65 cm, this is equivalent to 1.3 km/d. On the first 4 d after separation, control calves took an average of 8,887 steps/d more than two-stage calves ($P < 0.05$), which is equivalent to 5.8 km/d, if the same stride length is applied. On the day following separation (d 1), control calves walked approximately 11.5 km/d (17,637 steps/d) more than calves weaned in two stages (Figure 6). The magnitude of treatment differences in the distance traveled decreased ($P < 0.06$) after 48 h following separation (d 2). Over the period from 4 d before to 4 d after separation, two-stage calves took 4,084 fewer steps per day, or walked an estimated 2.7 fewer km/d ($P < 0.01$) than control calves.

Discussion

In Trial 1, we confirmed previously anecdotal observations (Haley et al., 2001) that cow-calf pairs spend their time in closer physical proximity to one another when nursing is prevented than pairs whose calves can still nurse, at least during the short-term period after nursing is terminated (2 d in this study). In contrast, calves that had been prevented from nursing for a longer period (12 and 13 d) were observed to be at a similar distance from their dams as calves that could nurse were from their dams. Previous research has indicated that preventing nursing between pairs, but allowing them all other forms of social interaction, resulted in relatively subtle behavior changes (Veissier and le Neindre, 1989; Haley et al., 2001). The previous studies were all conducted under drylot pen conditions, and data presented herein represent the first observations of pairs prevented from nursing under pasture conditions.

The distance between a cow and her calf has been reported to increase with time since their last nursing,

Table 1. Average daily gain (kg) by calves weaned by separation (Control) or in two stages with nursing deprived for 5 d before separation (d 0) in Trials 2 and 3

Trial—Farm	Days[a]	Control	Two-stage	SE	*P*-value
Trial 2—Termuende[b]	–5 to 0	1.04	1.09	0.21	0.86
	0 to 7	0.66	0.91	0.11	0.10
(n = 100)	0 to 28	0.99	0.94	0.07	0.67
	–5 to 28	0.99	0.96	0.06	0.70
Trial 3—Goodale[c]	–5 to 0	1.52	0.59	0.21	0.003
	0 to 7	1.17	1.84	0.14	0.001
(n = 52)	0 to 28	0.65	0.94	0.09	0.03
	–5 to 28	0.78	0.89	0.07	0.29
Trials 2 and 3 combined	–5 to 0	1.15	0.92	0.16	0.30
	0 to 7	0.95	1.37	0.09	0.001
(n = 152)	0 to 28	0.85	0.92	0.06	0.40
	–5 to 28	0.90	0.92	0.04	0.73

[a]Average daily gain was measured for the 5 d before separation (–5 to 0), the 7 d following separation (0 to 7), for 28 d following separation (0 to 28), and from 5 d before separation to 28 d after separation (–5 to 28).

[b]Trial 2 was conducted with an equal number of steers and heifers at the Termuende farm.

[c]Trial 3 was conducted with heifer calves at the Goodale farm.

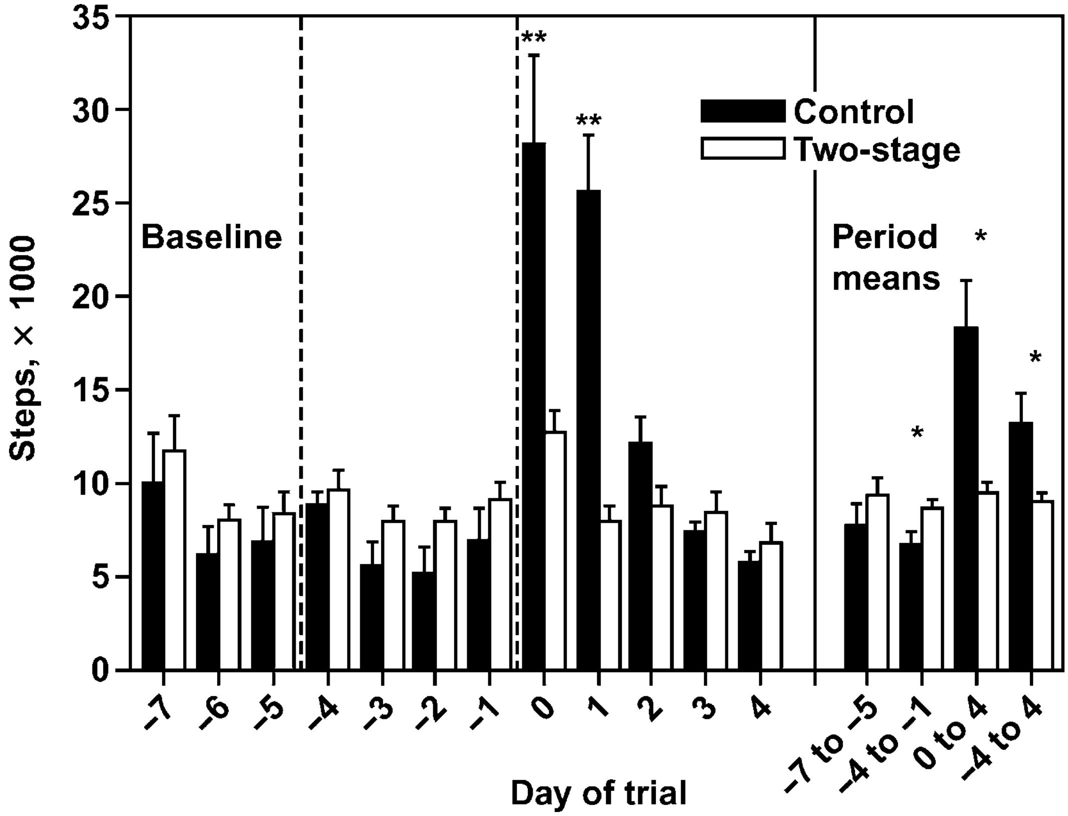

Figure 6. Mean (± SE) number of steps taken for each day of Trial 4 by calves weaned in two-stages and by the traditional method of separation (control). Two-stage treatment calves (n = 5) were prevented from nursing by placing a nose-flap, antisucking device for 5 d before separation, and control calves (n = 5) were weaned by the traditional approach of removing calves from their dam without prior prevention of nursing. Overall treatment effects are presented on the far right, for the baseline period when all pairs were free to nurse (d –7 to –5), the 4-d period when two-stage calves were prevented from nursing (d –4 to –1), the 5 d after all calves were separated from their mother (d 0 to 4), and the overall study (d –4 to 4). **Indicates differences between treatments on specific days, $P < 0.001$. *Indicates treatment differences within each of the four periods, $P < 0.05$.

up to a critical point, after which the individuals initiate reunion by increasing the time they spend walking and vocalizing (Watts, 2001). Nursing may decrease the motivation of cows and calves to be close together. Physical proximity between mother and offspring also has been suggested as a possible measure of the attachment that exists between a cow and a calf (Gubernick, 1981). Maintaining a closer distance is assumed to reflect a stronger bond. Maintaining proximity in the present context might also reflect increased motivation to nurse. It is not clear whether the mother or the offspring may be more responsible for maintaining this close physical contact.

Observations following separation of the cow and calf in Trial 1 are similar to those reported by Haley et al. (2001). Results of both studies clearly demonstrate that calves weaned in two stages vocalize less, walk less, and spend more time eating and resting/lying after separation than control calves that are weaned by the traditional method of abrupt separation.

The process of transportation is assumed to be a significant compounding stressor that may contribute to the disruption of normal calf behavior at weaning. In Trial 1, however, any effects of transportation on the behavior of newly weaned calves did not negate the differences between control and two-stage weaning treatments in vocalization rate and time spent eating, resting, and walking after separation. Similar to Trial 1, two-stage calves walked less than control calves for 2 d after separation in Trial 4.

Watts (2001), observing pairs that separated naturally under extensive pasture conditions, reported that both cows and calves increased their rate of vocalizing and spent more time walking, which culminated in reunion and nursing. Milk deprivation also results in increased vocalization by young dairy calves, even when they are not being reared with their dam (Thomas et al., 2001). Certain behavior patterns are mutually exclusive (e.g., walking and lying), and so not all changes in behavior can be considered as independent. Decreased time spent eating and resting may be indirect results of calves spending more time vocalizing and walking.

The significant increase in walking behavior by control calves in Trial 1 may be considered surprising given the limited space and stocking density (six calves per 5×10 m pen, or 8.3 m^2/calf). Regarding environmental effects on the response of calves to weaning, Price et al. (2003) reported that after traditional weaning by abrupt separation, calves kept on pasture (6,900 to 45,700 m^2) walked significantly more than calves housed in drylot pens (288 m^2). Therefore, in our study treatment differences may have been greater if calves were given more space in which to walk.

Behavior results from Trial 4 further emphasize the treatment effects on walking and the distance traveled by calves after separation. Walking behavior quantified with pedometers designed for humans agreed with data collected previously by instantaneous scan sampling methods (Haley et al., 2001). Unfortunately, pedometers cannot record the intensity of walking behavior (e.g., whether calves moved at a trot or a slow walk), but they offered us the opportunity to record walking for a 24-h period, which is often logistically impractical by live observation. Although control calves walked less than two-stage calves during the period when nursing was prevented, the advantage of the two-stage treatment over the control after separation was much greater in magnitude. Over 4-d periods in Trial 4, the increase in walking by two-stage calves when nursing was deprived was less than one-third the increase of walking by control calves after separation.

Results from our evaluation of ADG for calves were not consistent across all the trials in this study, and we found limited evidence that suggested two-stage calves gain better than control calves after separation. In all three trials, two-stage calves had improved performance during the first week after separation, and in Trial 3, two-stage weaned calves had greater ADG during the 4-wk period after separation. Two-stage calves may have had greater ADG during the first week after separation because they spent more time eating than control calves, which were recorded vocalizing more frequently and spending more time walking during the second and third day following separation.

In two of three trials, control calves gained more weight than treated calves during the period when two-stage calves were being deprived of nursing. This result is not surprising, as control calves would be expected to benefit from the nutrition in the milk they were receiving. In Trial 2, in which ADG did not differ between weaning treatments, the quality of the pasture was better than in Trials 1 and 3. The availability of good-quality pasture in Trial 2 may have allowed two-stage calves to compensate immediately for the loss of maternal milk. By comparison, the poorer pasture conditions (dormant forage, moderate utilization levels) in Trials 1 and 3 may not have been sufficient to replace nutrients provided in the milk. It is proposed that low-quality pasture was a major factor contributing to the large differences in ADG observed between the long two-stage weaning and control groups in Trial 1. Considered together, these findings emphasize the fact that, at least nutritionally, two-stage calves should be considered weaned as soon as they are prevented from nursing. To ensure that ADG does not decrease in Stage 1, nutritional management of two-stage calves should be carefully considered as soon as nursing is deprived, which was not considered in any of our trials.

Under the experimental designs reported herein, control calves always had the advantage of a greater number of days nursing, which also might explain some of the inconsistencies in ADG among treatments. Perhaps another useful treatment group in the present trials could have been a second control group weaned on the same day that nursing was terminated for the two-stage calves, equalizing the number of days that calves spent nursing. Although the evaluation of ADG from the termination of nursing to the end of the study was potentially confounded by the number of days and management during the period before separation, only the long two-stage calves had lower ADG than calves weaned by traditional separation after nursing ended. In three separate trials, ADG by the two-stage calves (nose-flaps used for 3 to 5 d before separation) was equal or superior to that by controls when evaluated from the end of nursing.

Weaning by abrupt, remote separation typically imposes physical separation of the mother and offspring, which is very different from the natural weaning process. After prolonged physical separation, cows and calves invoke behavioral strategies such as increased vocalizing and increased walking, which help them reunite (Watts, 2001). Abrupt weaning by the separation of cows and calves activates these two primary behavior response patterns. Two-stage weaning more closely simulates natural weaning by terminating nursing, albeit artificially, while the cow and calf are still together.

Despite some reservations from present trials regarding ADG when nursing is deprived, two-stage weaning represents a practical approach to minimize behavioral aspects of weaning distress in beef cattle. Nose-flaps are relatively inexpensive (less than \$1.00 each) and can be reused after a recommended disinfection. Nose-flaps can be placed and removed in a few seconds if the calf is restrained (e.g., squeeze chute). The rate of retention for the nose-flaps in these studies was 95% or greater.

Slight changes to the experimental design should be implemented in any further evaluations of ADG to equalize the number of days calves spend nursing. In addition, the quality of the available nutrients should be carefully considered during the period when nursing has been deprived, and the period that antisucking devices remain on calves before physical separation should be limited to 4 or 5 d. The possible implications of decreasing weaning stress on the health of calves also should be further investigated. Although calves were our focus in the present series of trials, distance traveled and vocalizations by cows may be decreased with two-stage weaning (Haley et al., 2001; our unpublished data), and we also consider the possible benefits for cows worthy of further investigation.

Literature Cited

Gubernick, D. J. 1981. Parent and infant attachment in mammals. Pages 243–305 in Parental Care in Mammals. D. J. Gubernick and P. H. Klopfer, ed. Plenum, New York, NY.

Haley, D. B., J. W. Stookey, J. L. Clavelle, and J. M. Watts. 2001. The simultaneous loss of milk and maternal contact compounds distress at weaning in beef calves. Page 41 in Proc. 35th Int. Cong. Int. Soc. Appl. Ethol. J. P. Garner, J. A. Mench and S. P. Heekin, ed. Davis, CA. The Center for Animal Welfare, University of California, Davis.

Lehner, P. N. 1996. Handbook of Ethological Methods. 2nd ed. Cambridge Univ. Press, Cambridge, U.K.

Neumann, A. L. 1977. Beef Cattle. 7th ed. John Wiley & Sons, New York, NY.

Price, E. O., J. E. Harris, J. E., Borgwardt, M. L. Sween, and J. M. Connor. 2003. Fenceline contact of beef calves with their dams at weaning reduces the negative effects of separation on behavior and growth rate. J. Anim. Sci. 81:116–121.

Pritchard R. H., and J. K. Mendez. 1990. Effects of precondition on pre- and post-shipment performance of feeder calves. J. Anim. Sci. 68:28–34.

Stookey, J. M., K. S. Schwartzkopf-Genswein, C. S. Waltz, and J. M. Watts. 1997. Effects of remote and contact weaning on behavior and weight gain of beef calves. J. Anim. Sci. 75(Suppl. 1):83. (Abstr.)

Thomas, T. J., D. M. Weary, and M. C. Appleby. 2001. Newborn and 5-week-old calves vocalize in response to milk deprivation. Appl. Anim. Behav. Sci. 74:165–173.

Veissier, I., and P. Le Neindre. 1989. Weaning in calves: Its effect on social organization. Appl. Anim. Behav. Sci. 24:43–54.

Watts, J. M. 2001. Vocal behaviour and welfare in cattle. Ph.D. Thesis, Univ. of Saskatchewan, Saskatoon, Canada.