Effects of Housing and Colostrum Feeding on Serum Immunoglobulins, Growth, and Fecal Scores of Jersey Calves[1]

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ABSTRACT

Ninety-six Jersey calves were used to evaluate the effects of housing and method of colostrum feeding on serum Ig concentrations, incidence and severity of scours, intake, and BW changes from birth to 35 d of age. Calves were separated from the dam and fed 2 L of colostrum in nipple-bottles or allowed to nurse the dam for 3 d. Calves were housed in individual hutches or wooden pens in a barn. Intake of colostrum by calves allowed to nurse the dam was not controlled. Serum IgG and IgM concentrations at 24 h of age were greater for calves that nursed the dam. Scours were less severe when calves were housed in hutches, but number of days scouring was unaffected by treatment. Calves fed colostrum in nipple-bottles and housed in the barn consumed more starter than did other calves from 3 to 5 wk of age. The BW were greater for calves allowed to nurse the dam and housed in hutches. Feed efficiency over the 35-d study was improved when calves nursed the dam. Optimal transfer of passive immunity and housing in hutches appeared to maximize health and growth in this study. (**Key words**: disease, colostrum, housing, Jersey)

INTRODUCTION

A large proportion of dairy calves in the US develop diarrhea during the first 2 mo of life (7). Mean mortality of preweaned calves is 8.4% in the US (SE = .4); >52% of fatalities are associated with scours (7). Therefore, management of calves often involves attempts to minimize the spread of infectious organisms and initiation of treatment when scours develop. Two factors that influence the incidence and severity of scours are colostrum feeding and housing.

The importance of consumption of an adequate amount of colostrum on acquisition of passive immunity is widely recognized (10). However, less clear are effects of the method of feeding colostrum on serum Ig concentration and subsequent health. Failure of transfer of passive immunity is greater when calves are allowed to suckle (4, 6, 25), although efficiency of Ig absorption is improved (27). Calves left with the dam for 72 h may be exposed to greater numbers of infectious organisms associated with the dam and environment, thereby increasing the risk of disease.

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Housing also affects incidence and severity of scours (8, 16, 29). Calves raised in hutches are less likely to be treated for scours than are calves raised in individual pens in a calf barn (29). However, other reports (15, 19) indicate that overall calf management influences morbidity more than housing system.

Methods of housing and feeding colostrum may alter the exposure to infectious organisms, which may predispose calves to scours, thereby reducing intake and BW gain. Therefore, our objectives were to determine the effects of housing and method of colostrum feeding on the incidence and severity of scours, intake, BW gain, and feed efficiency for neonatal Jersey calves.

MATERIALS AND METHODS

Experimental Design

Jersey cows (n = 101) were housed in a drylot until approximately 2 d prior to parturition, when they were moved to an individual calving pen bedded with straw. At birth, calves were blocked by sex (48 heifers and 48 bull calves) and date of birth and assigned to one of four treatments in a randomized complete block design. Calves were allowed to nurse the dam for 3 d or were separated from the dam and fed 1 L of colostrum in nipple-bottles at 0 and 12 h after birth and housed in individual fiberglass hutches or individual pens in an unheated calf barn. Stillborn calves (n = 4) and 1 calf that died at 3 d of age were replaced, and 6 other calves that died during the study were not replaced; therefore, a total of 90 calves completed the study.

Calves fed colostrum from nipple-bottles were moved to the hutch or barn before nursing. The unheated calf barn contained 40 individual wooden pens (1.2 × 2.4 m) and housed calves prior to the initiation of the study. Mechanical ventilation was provided in the barn throughout the study. Calf hutches were located in an area not previously exposed to calves. Pens and hutches were thoroughly washed, disinfected, and allowed to dry prior to use. Hutches were moved to a new location after each use. Calf pens and hutches were bedded with a minimum amount of sawdust and straw to facilitate estimation of fecal scores.

Feeding Management

Calves fed by nipple-bottle were fed first milking colostrum from the dam. Cows were milked by hand, and a 50-ml sample of colostrum was obtained and stored (–20°C) prior to compositional analysis (24). Calves were fed 1 L of colostrum as soon as possible after birth and again 12 h later. Following the second feeding, calves were fed 1 L of colostrum twice daily to 3 d of age using second and third milking colostrum from the dam.

Calves that nursed the dam were observed for the first 4 h after birth and were assisted if nursing did not commence by 4 h. Thereafter, calves were left with the dam until 3 d of age. No attempt was made to measure quantitatively the amount of colostrum consumed by nursed calves.

Commercial calf starter (Tennessee Farmers Cooperative, LaVergne, TN) was offered for ad libitum consumption from d 3. Starter was formulated to contain a coccidiostat (Deccox®; Rhône-Poulenc, Atlanta, GA) at 25 mg/kg. Commercial milk replacer (Land O'Lakes, Inc., Ft. Dodge, IA) was reconstituted to 12% DM and fed twice daily (.95 L per feeding) from 3 to 35 d of age. Milk replacer was formulated to contain oxytetracycline (138 mg/kg) and neomycin base (250 mg/kg). Refused milk replacer and calf starter were weighed and reported daily. Water was available at all times. Second-cutting alfalfa hay was offered for ad libitum consumption after 14 d. Although hay orts were not measured, few calves consumed significant quantities of hay.

Calves were weighed at birth and every 7 d thereafter to 35 d. Milk replacer, calf starter, and hay were sampled monthly and analyzed for DM, CP, ash (2), NDF (11), and minerals.

Sample Collection and Analysis

Incidence and severity of scours were estimated at the a.m. feeding by the method of Larson et al. (17). When fecal score exceeded 2 or when a calf exhibited other signs of disease (fever, cough, or congestion), antibiotic therapy was initiated. Scours were also treated with electrolyte therapy (Enterim-5™; Shering-Plough Animal Health, Kenilworth, NJ); milk replacer was not discontinued during electrolyte therapy.

Fecal grab samples were collected from all calves every Tuesday and Friday during the study to determine the prevalence of rotavirus, coronavirus, K99+ *Escherichia coli, Cryptosporidium, Giardia*, and *Eimeria* (23).

Approximately 10 ml of jugular blood were taken at 24 h after birth and allowed to clot. Serum was separated by centrifugation (3000 × *g*) and frozen (–20°C) until analysis in duplicate for IgG and IgM by radial immunodiffusion (VMRD, Inc., Pullman, WA).

Statistical Analysis

Weekly mean fecal scores, number of days of scouring per week, BW gain, feed efficiency, and days × fecal score were analyzed as a randomized complete block design in a repeated measures analysis of covariance using a general linear mixed models algorithm (5). Terms in the model were block, treatment, block × treatment, week of age, week × treatment, and error. Block × treatment was used as the error term to test the effects of treatment, and error was used to test week and week × treatment. Intake and BW data could not be measured by repeated measures analysis of covariance because of heterogeneity of error variance. Therefore, data were analyzed by pooling of data across weeks and analysis as a randomized complete block design. Weekly intake and BW data were analyzed by the method of Allen et al. (1) using cubic regression to obtain coefficients for each calf, which were subjected to multivariate analysis of covariance. Serum Ig concentrations at 24 h of age were analyzed as a randomized complete block design. All data were covariately adjusted for BW at birth. Data from calves that died during the experiment were removed prior to analysis. Significance at $P < .05$ was used unless otherwise noted.

RESULTS AND DISCUSSION

Mortality and Serum Ig

Mean mortality was 10.9% for all calves during the experiment and 7.2% for calves born alive. Serum IgG and IgM concentrations at 24 h were generally low for calves that died, although serum IgG exceeded 30 g/L in 2 calves. Although the amount of protection provided by serum Ig is dependent on environment and exposure to pathogens, serum IgG_1 (4) or IgG (10) concentrations <10 g/L have been used to denote the failure of transfer of passive immunity. Under the assumption that 80 to 90% of IgG is IgG_1, serum IgG concentrations <10 to 13 g/L indicate failure of transfer of passive immunity. Using this criterion, 3 of 7 calves (43%) that died failed to achieve acceptable transfer of passive immunity.

Serum IgG and IgM concentrations at 24 h were greater when calves were allowed to nurse the dam (Table 1). Serum IgG concentrations in this study were greater than those in reports on Holstein calves (3, 27, 28). Tennant et al. (28) also reported that serum Ig was higher for Jersey than for Holstein calves and attributed differences in serum Ig to improved efficiency of Ig absorption.

Absorption of Ig improved when calves were allowed to nurse the dam (27), although the biological basis for improved absorption has not been determined. Calves that were allowed to suckle may have consumed more colostrum than bottle-fed calves and, therefore, had higher serum Ig concentrations. However, others have indicated that calves allowed that were to nurse consumed smaller amounts of colostrum (4, 27), began consuming colostrum at a later age than calves fed colostrum by bottle (25), or failed to suckle altogether (25). Brignole and Stott (6) reported that 30 to 40% of calves left with the dam failed to obtain sufficient passive immunity.

Apparent efficiency of IgG absorption in calves fed by nipple-bottle (calculated as serum IgG concentration × BW × .07/g of IgG intake) was negatively correlated with colostral IgG concentration ($r = -.53$; $P < .001$), which supports the hypothesis that Ig absorption from colostrum is linearly related to colostral Ig concentration (26). Mean consumption of IgG and IgM for calves fed by nipple-bottle was 138.2 and 5.2 g over 24 h, respectively, and ranged from 56.8 to 336.2 and .5 to 16.4 g, respectively.

Fecal Scores

Fecal score was ≥2 for all calves on at least 1 d of the study and was recorded for 30.6% of days on the study (n = 963). No differences were observed among treatments in number of days of scouring (10.3 d; SE = .4). Mean fecal scores were greater when calves were housed in the barn (Table 1), indicating that environment affected the severity of scouring, regardless of method of colostrum feeding.

Total weekly fecal scores (Figure 1) were affected by period and by an interaction of period × treatment ($P < .002$). Single degree of freedom contrasts were used to determine the effects of treatment within week. Weekly scores (days of scouring × fecal score) markedly increased for all treatments during wk 2 and then declined to the end of the study. Incidence of scours generally increases during the first 2 to 3 wk of life when rotavirus, coronavirus, and *Cryptosporidium* are primary infectious organisms (12, 18, 22). Fecal scores during the first 2 wk of age were greater for calves fed colostrum by nipple-bottle ($P < .001$) than for those nursing the dam. However, fecal scores were greater at 2 wk of age and lower at 3 wk of age for calves fed colostrum by nipple-bottle and housed in the barn. Consequently, severity and frequency of scours for these calves occurred at an earlier age than for calves on other treatments ($P < .01$). Because the calf barn used in this study housed calves previously, calves placed in the barn may have been exposed to a greater number and variety of potentially pathogenic organisms. Calves fed via nipple-bottle had lower serum Ig concentrations (Table 1) and probably were less well protected against the greater infectious challenge, which increased fecal scores. Fecal scores for those calves at 3 wk may have been lower because calves were exposed to one or

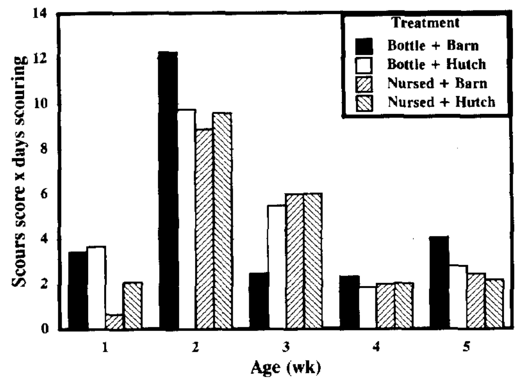

Figure 1. Weekly fecal scores of calves fed colostrum via nipple-bottle or allowed to nurse the dam and housed in calf hutches or in individual pens in a calf barn. Standard error = .8.

TABLE 1. Least squares means (pooled across weeks) of serum Ig concentration and extent and severity of scouring of Jersey calves that were fed colostrum by nipple-bottle or allowed to nurse the dam and housed in individual hutches or pens in a calf barn.

Item	Treatment				SE	Contrast[1]		
	Bottle + barn	Bottle + hutch	Nursed + barn	Nursed + hutch		1	2	3
n	22	21	24	23	. . .			
Mortality,[2] %	8.3	12.5	0	4.2	. . .			
Serum IgG,[3] g/L	24.4	23.2	36.1	39.4	2.1	***	NS[4]	NS
Serum IgM,[3] g/L	2.9	2.6	3.4	3.5	.3	*	NS	NS
Age at scouring, d	17.0	19.7	21.2	19.5	1.0	*	NS	*
Days of scouring[5]	10.6	10.7	9.5	10.2	.8	NS	NS	NS
Fecal score[6]	2.51	2.43	2.51	2.42	.05	NS	*	NS

[1]Contrasts: 1 = effect of colostrum feeding, 2 = effect of housing, and 3 = interaction of colostrum feeding × housing.

[2]Mortality of calves born alive.

[3]Covariately adjusted for BW at birth.

[4]$P > .10$.

[5]Total number of days with fecal score ≥2.

[6]Mean score for fecal scores ≥2.

*$P < .05$.

***$P < .001$.

more infectious agents during the first 2 wk of age and had subsequently recovered. Others (8, 16, 19, 29) have recommended housing calves in individual hutches as an effective method to minimize contact among calves and, consequently, prevalence of disease. Reduction of fecal scores by .09 units (3.4%) supports this hypothesis, but reductions in morbidity were not as marked as those in other studies (29). Although contact between calves is minimized, pathogens can be transferred to isolated calves by farm workers and other vectors.

Factors Affecting Fecal Scores

Stepwise multiple regression was used to determine variables affecting the incidence and severity of scours in calves during the study. Dependent variables were weekly incidence of scours (1 = fecal score ≥2 at least once per week; 0 = no scours occurred during the week), severity of scours (mean of fecal scores ≥2 during the week), numbers of days of scouring per week, and mean fecal score × number of days of scouring. Independent variables included prevalence of rotavirus, coronavirus, *Eimeria*, *Giardia*, and *Cryptosporidium*, week of age, serum IgG and IgM concentrations, colostral IgG and IgM concentrations, sex, housing (barn vs. hutch), method of colostrum feeding, interaction of housing × method of colostrum feeding, date of birth, mean daily BW gain, DMI, and intakes of starter and milk replacer. Squared and logarithmic terms of quantitative independent variables were also included in the model. Variables entered the model and were retained in the model if significance was $P \leq .05$.

Results of all regressions indicated that the prevalence of *Cryptosporidium* was the most significant factor influencing the incidence of scours, severity of scours, and the number of days of scouring per week in this herd (Table 2). Prevalence of rotavirus also contributed to the incidence and severity of scours, but to a lesser extent than *Cryptosporidium*. Other organisms measured did not significantly contribute to incidence or severity of scours. The coefficient for mean daily BW gain was negative in all regressions, indicating that increasing incidence or severity of scours reduced BW gain. The highly negative coefficient for mean daily BW gain in regression of days ×

TABLE 2. Regression coefficients of weekly incidence of scours, number of days scouring per week (D), mean weekly fecal score (S), and D × S.

Item	Incidence	*F*	*P*	D	*F*	*P*	S	*F*	*P*	D × S	*F*	*P*
Intercept	19.154	5.5	*	2.087	70.4	***	–.033	.1	NS[1]	4.703	56.6	***
Rotavirus[2]	.175	7.5	**	.813	11.3	***	.476	8.1	**	2.183	11.1	***
Cryptosporidium[2]	.205	15.3	***	1.666	70.3	***	.672	23.5	***	4.629	73.7	***
Sex[3]				–.344	3.8	*						
Mean BW gain, kg/d	–.268	9.7	**	–1.110	12.3	***	–.771	12.0	***	–3.033	12.4	***
Milk DMI,[2] g × 10^{-6}/d	1	8	**				8	7	**			
Milk DMI, log g/d	–2.868	5.2	*									
Serum IgG, g/L	–.005	6.3	**				–.014	8.2	**			
Serum IgM, g/L	–.032	4.0	*							–.308	3.9	*
Colostral IgG, g/L	–.003	5.3	*									
Serum IgM, log g/L				–.407	4.7	*						
R^2		.22			.31			.20			.31	

[1]$P > .10$.

[2]Prevalence of organism: 1 = present in fecal sample, and 0 = absent.

[3]Sex of calf: 1 = female, and 0 = male.

*$P < .05$; **$P < .01$; ***$P < .001$.

TABLE 3. Chemical composition[1] of feeds used.

Item	Milk replacer		Calf starter		Hay	
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE
DM, %	95.0	.5	90.4	.3	92.4	.8
	(% of DM)					
CP	21.8	.1	22.0	.4	17.3	.3
Ash	13.3	.1	7.6	.1	9.8	.1
NDF	ND[2]		11.7	.1	47.2	.8
Ca	.8	.1	1.4	.1	.5	.1
P	1.2	.1	.9	.1	.4	.1

[1]n = 2.

[2]Not determined.

severity (Table 2) indicated that BW gain was markedly reduced when scouring was severe or lasted for an extended period. Serum IgG and IgM concentrations and colostral IgG concentration were significant in one or more regression equations, reemphasizing the importance of transfer of passive immunity to minimize the incidence and severity of scours. Serum IgM was related to incidence of scours, number of days of scouring, and interaction of days × severity; serum IgG was related to incidence and severity of scours. Milk replacer intake was negatively related ($P < .01$) to incidence and severity of scours because milk replacer was refused only when calves scoured severely.

The regression coefficient for sex was significant for number of days of scouring, indicating that heifers scoured fewer days than bulls. Mean number of days of scouring for bulls and heifers was 1.9 and 1.6 d/wk (SE = .1), respectively.

Growth, Intake, and Feed Efficiency

The CP in calf starter (Table 3) was higher than NRC recommendations (21) for starters, and protein and NDF in hay were typical of medium quality forage.

Calves left with the dam were not offered milk replacer until 4 d of age. From d 4 to the end of the study, intake of milk replacer did not vary by treatment. Milk replacer refusals were minimal and occurred only when the calf exhibited severe scours; consequently, differences in DMI were caused by differences in starter intake. Intakes of calf starter, DM, and CP over the 35-d study were greater for calves fed colostrum in nipple-bottles (Table 4). An interaction of colostrum feeding × housing tended toward significance ($P < .10$), indicating that calves fed colostrum in nipple-bottles and housed in the barn consumed more calf starter, DM, and CP than other calves. Multivariate ANOVA of starter intake regression coefficients (Table 5) indicated a significant effect of housing on the change in starter intake during the study. Calves housed in the barn, but particularly those fed colostrum in nipple-bottles, consumed more starter than other calves, primarily during the last wk 3 of the study. Also, during wk 5, starter intake did not increase as rapidly when calves were housed in the barn, as indicated by the more highly negative cubic regression coefficients (–86 vs. –15; $P < .01$). Decreasing rate of increase in starter consumption during wk 5 may have been due to greater prevalence of *Eimeria* in feces of calves housed in the barn during wk 4 and 5. Although weekly fecal scores were not markedly increased by the prevalence of *Eimeria*, damage to intestinal epithelium may influence intake and digestibility (9). Mean daily intake of decoquinate was .01, .04, .18, .37, and .47 mg/kg of BW from wk 1 to 5, respectively, which was lower than the amount (.5 mg/kg of BW) required to minimize incidence of coccidiosis in dairy calves, although smaller amounts may partially suppress fecal oocyst discharge and diarrhea (20). Calf starter DMI averaged 465 g at 35 d, which was slightly lower than those amounts recommended for weaning (14).

Calf BW at 35 d and BW gain from 0 to 35 d were affected by an interaction of colostrum feeding × housing. Calves that were allowed to nurse the dam and housed in hutches were heavier at the end of the study than other calves (Table 4). Regression coefficients of BW over time (Table 5) also tended ($P < .10$) to be affected by colostrum feeding, indicating that growth patterns differed by treatment; most differences in BW occurred during the last 2 wk of the study. Mean BW change was −11 and 118 g/d during the first 2 wk, respectively. Prevalence of *Cryptosporidium* was particularly high during the first 2 wk of life, which probably contributed to increased scours and BW changes. Thereafter, BW gain increased with age, but most rapidly in calves allowed to nurse the dam and housed in hutches. Prevalence of *Cryptosporidium* and *Eimeria* oocysts was lower, and prevalence of rotavirus tended to be lower, in feces of calves housed in hutches, which may have contributed to differences in BW gain. The combination of improved overall health of calves nursing the dam and reduced exposure to *Cryptosporidium*, *Eimeria*, and rotavirus by housing in hutches may have contributed to increased rate of BW gain, particularly in the last 2 wk of the study.

Stepwise multiple regression indicated that weekly BW gain increased as age and CP intake increased. The number of days of scouring and the prevalence of rotavirus and *Cryptosporidium* reduced BW gain, suggesting that management related to minimizing prevalence of these organisms would have been most effective in improving the growth of the calves used in this study.

Efficiency of feed and CP use pooled across all weeks of the study were improved when calves were allowed to nurse the dam (Table 4). Improved efficiency of feed use was not due to the lower intake of starter because starter intake was not significant when included as a covariable in the analysis of DM or CP efficiency.

Heinrichs et al. (13) proposed that calf housing and management interact to influence health and growth of calves. Our data support this hypothesis, particularly in relation to the method of colostrum feeding and the acquisition of passive immunity. In our study, assisted nursing (ensuring that all calves nursed the

TABLE 4. Least squares means[1] (pooled across weeks) of intake, BW gain, and feed efficiency in Jersey calves that were fed colostrum by nipple-bottle or allowed to nurse the dam and housed in individual hutches or pens in a calf barn.

	Treatment					Contrast[2]		
Item	Bottle + barn	Bottle + hutch	Nursed + barn	Nursed + hutch	SE	1	2	3
BW								
At birth, kg	25.0	24.1	26.0	25.9	.6	*	NS[3]	NS
At 35 d, kg	33.2	31.7	32.4	35.3	1.0	NS	NS	*
Gain, g/d	226	182	204	287	28	NS	NS	*
Intake								
DM,[4] g/d	455	409	388	397	17	**	NS	†
CP,[4] g/d	111	99	93	96	4	**	NS	†
Starter, g/d of DM	223	177	156	165	16	**	NS	†
Milk replacer, g/d of DM	231	232	232	232	1	NS	NS	NS
BW Gain:DMI, g/kg	548	504	567	666	47	*	NS	NS
BW Gain:CP intake, g/kg	2251	2105	2393	2784	190	*	NS	NS

[1]Adjusted for BW at birth by analysis of covariance, except BW at birth.

[2]Contrasts: 1 = effect of colostrum feeding, 2 = effect of housing, and 3 = interaction of colostrum feeding × housing.

[3]$P > .10$.

[4]Does not include hay intake, which was not measured.

†$P < .10$.

*$P < .05$.

**$P < .01$.

TABLE 5. Least squares means of regression coefficients of starter DMI and BW of Jersey calves fed colostrum by nipple-bottle or allowed to nurse the dam and housed in individual hutches or pens in a calf barn. Independent variable in regressions was age (week).

	Treatment								Contrast[1]		
	Bottle + barn	SE	Bottle + hutch	SE	Nursed + barn	SE	Nursed + hutch	SE	1	2	3
Starter DMI, g/d									NS[2]	*	NS
Intercept	1326	269	475	283	1159	255	562	263			
Linear	−2244	421	−786	444	−1869	401	−920	413			
Quadratic	1029	182	324	191	807	173	386	178			
Cubic	−97	22	−10	23	−74	21	−20	21			
BW, kg									†	NS	NS
Intercept	26.19	1.20	26.59	1.26	27.77	1.14	26.61	1.17			
Linear	−2.49	1.72	−2.67	1.81	−3.10	1.64	−1.73	1.69			
Quadratic	1.24	.75	1.18	.78	1.32	.71	.73	.73			
Cubic	−.09	.09	−.08	.10	−.10	.09	.01	.09			

[1]Contrasts: 1 = effect of colostrum feeding, 2 = effect of housing, and 3 = interaction of colostrum feeding × housing.

[2]$P > .10$.

†$P < .10$.

*$P < .05$.

dam by 4 h of age) promoted increased serum IgG and IgM concentrations, decreased prevalence and severity of scours, number of days of scouring, and improved feed efficiency. Although allowing calves to nurse the dam can increase the potential for failure of transfer of passive immunity, assisting calves to nurse the dam may alleviate some problems associated with failure to suckle or delayed suckling. However, the amount of time and management required to assist calves to suckle may preclude widespread use of this practice. A recent survey of dairy producers in the US indicated that 13.8% of producers assisted calves in nursing the dam compared with 64% who fed first colostrum via bucket or bottle, 19.9% that allowed unassisted nursing, and 2.3% that fed colostrum via esophageal feeder (7).

CONCLUSIONS

Methods of housing and colostrum feeding affected the incidence and severity of scours, growth, and intake of young calves in this study. Allowing the calf to nurse the dam increased serum IgG and IgM concentrations at 24 h of age. Most scours occurred during the first 3 wk of age and were a result of the prevalence of *Cryptosporidium* and rotavirus. Housing in the barn increased fecal scores, probably as a result of increased exposure to *Eimeria* and rotavirus. Isolation of calves by housing in hutches and maximizing transfer of passive immunity by allowing calves to nurse the dam increased BW gain and improved health of calves in this study.

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