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Original Research Paper

INFLUENCE OF COLOSTRUM QUALITY ON THE HEALTH STATUS AND GROWTH OF CALVES

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Summary: Thirty six calves were monitored from birth through to the age of 24 weeks. The Ig content of their dam's colostrum was measured via a colostrometer and indirectly by measuring the enzyme activity of the gamma-glutamyl transferase (GGT) or the concentration of total-serum protein (TSP) in the calves' sera during their first week of life. The concentration of albumin (Alb) and leukocyte count (WBC) in calf serum were also measured. The health status and chest girths of the calves were also regularly recorded.
The mean chest girths of the ill and healthy calves did not differ significantly. The Ig concentration in the colostrum had a statistically significant influence on the TSP and GGT but not on the Alb and WBC. The interval between birth and the first intake of colostrum had a statistically significant influence on GGT and WBC, but not on the TSP and Alb. In the calves that fell ill the only statistically significant influence their illness had was on WBC. The correlation between the Ig concentration in colostrum and TSP and GGT in a calf's serum was highly significant, as was the correlation between the activity of GGT and the TSP and WBC.

Key words: calves; colostrum; immunology; health status; growth

Introduction

Calves are born without immunoglobulins (Ig), because the bovine epitheliochorial placenta is impermeable for protein macromolecules. They get Ig with the first intake of colostrum. The calf intestine is able to absorb macromolecules, like Ig, for 24 hours after birth. During this time enzyme activity is minimal, therefore Ig are not decomposed in the small intestine. It is crucial for the health of a calf to get an adequate amount of colostrum as soon as possible after birth. Calves that do not get an adequate supply of colostrum more often than not end up with an infection and have a higher mortality than other calves.

Morbidity and mortality in neonatal calves have complex aetiologies. Factors often linked to outbreaks of a disease are associated with an insufficient intake of colostrum, exposure to a potentially virulent pathogen, inadequate hygiene, and suboptimal nutritional support (1). Many studies have been performed to investigate the connection between immunoglobulin status and the health of calves (1, 2, 3) and the connection between colostrum quality and immunoglobulin concentrations in calves sera (4, 5).

The volume and Ig concentration of the ingested colostrum and the interval between birth and the first intake influenced the absorption of immunoglobulin. The latter is most important for Ig2G and IgM absorption (6, 7). The Ig concentration in colostrum can be measured with a colostrometer (8). It can also be indirectly estimated in a calf's serum by measuring the activity of the enzyme gamma-glutamyl transferase (GGT), which is highly concentrated in colostrum, and like Ig, is absorbed with passive transfer (9, 10). Another indirect way to estimate serum Ig is by measuring the amount of total-serum protein (TSP) (11).

For normal development and body-weight gain it is very important that calves are healthy. Calves that are ill gain body weight slowly, which has a negative influence on the cost efficiency of breeding (12).

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Table 1: Mean chest girths (cm) in calves with regard to age

Age in weeks	n	$\bar{x}$	SD	CV (%)	Min.	Max.
1	36	79.37	2.78	7.71	73.00	86.00
2	36	79.43	3.20	10.25	73.00	89.00
3	36	79.47	3.06	9.39	72.00	85.00
4	36	82.24	3.91	15.30	73.00	92.00
5	36	84.72	3.89	15.12	75.00	93.00
6	36	87.17	4.45	19.80	79.00	98.00
8	36	93.43	4.94	24.36	82.00	103.00
12	36	104.94	4.46	19.88	97.00	112.00
16	36	115.23	5.50	30.29	106.00	130.00
20	36	126.00	9.80	96.00	117.00	177.00
24	36	130.23	6.37	40.58	120.00	154.00

Table 2: Basic statistical data for the sera values - GGT, TSP and Alb; Ig in colostrum and WBC in blood

Parameter	n	$\bar{x}$	SD	CV %	Min.	Max.
GGT in U/L	36	437.17	406.47	85.90	30.00	1,762.00
TSP in g/L	36	54.13	7.04	13.02	41.60	74.40
Alb in g/L	36	26.70	1.90	7.11	23.10	32.60
Ig in mg/ml	35	93.28	33.41	35.81	20.00	155.00
WBC x 10^9/L	36	9.20	3.99	43.31	4.60	20.60

Table 3: Mean values for the activity of GGT and the concentrations of TSP and Alb in the sera and Ig in the colostrum of healthy and ill calves

	Healthy calves			Ill calves		
Parameter	n	$\bar{x}$	SD	n	$\bar{x}$	SD
GGT in U/L	24	564.48	457.41	12	345.33	290.07
TSP in g/L	24	55.87	7.34	12	51.69	6.01
Alb in g/L	24	26.14	1.47	12	27.49	2.19
Ig in mg/ml	24	96.50	7.01	12	89.00	9.46
WBC x 10^9/L	24	8.78	3.49	12	9.78	4.66

The aim of our research was to assess what influence that the interval between birth and the first intake of colostrum, and its quality, has on the health of a calf and the difference in weight gain between healthy calves and calves which were ill within their first 24 weeks of life.

Materials and methods

Thirty six dairy calves, 19 male and 17 female, which were born between October and November 2003 to a herd of 200 dairy cows, were monitored from birth until they were 24 weeks of age. The calves were kept in individual boxes for the first week after birth and in groups of 10 thereafter. Straw was used as litter throughout the study and it was regularly changed. For the first four days of life they took in 1-1.5 litre of their dam's colostrum and milk, they were fed three times a day. From the fifth day they were fed up to 4 litres of milk twice a day, from cows treated with antibiotics. During first week they suckled milk from a nipple pail. Thereafter, they drunk from a trough and had free access to the starter and hay. They were weaned at four months of age.

Table 4: Correlation coefficients for the investigated parameters

Parameter	Ig in colostrum mg/ml	GGT U/L	TSP g/L	Alb g/L	WBC x10^9/L
Ig in colostrum mg/ml	1.0000	0.3862 *	0.6328 ***	-0.1250 ns	0.1455 ns
GGT U/L		1.0000	0.3958 *	-0.2195 ns	0.3924 *
TSP g/L			1.0000	-0.0376 ns	0.0773 ns
Alb g/L				1.0000	-0.2008 ns
WBC x 10^9/L					1.0000

* $p < 0.05$
*** $p < 0.001$
ns not significant

Table 5: F-values, coefficient determination-R2 and presentation of the significance of influence on the investigated parameters

	F-values			
Sources of variability	GGT U/L	TSP g/L	Alb g/L	WBC x 10^9/L
Sex	2.56 ns	0.04 ns	8.70 **	4.29 *
Health status	0.06 ns	1.47 ns	2.99 *	4.54 *
Interval to first intake of colostrum	4.08 *	0.01 ns	0.00 ns	8.40 **
Ig concentration in the colostrum	4.45 *	14.29 ***	3.84 *	0.50 ns
R^2 (%)	28.73	37.29	45.47	29.65

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$
ns not significant

The calves received 1-1.5 litres of their dam's colostrum almost immediately after birth. A record was kept for each calf, noting its first intake of colostrum and the colostrum's quality, which was measured at 22 °C using a colostrometer (Bergophor, Germany) (8, 13). Throughout the study, a veterinarian, who was constantly in attendance, monitored the health of the calves and recorded the details (date, duration, type, etc.) of any disease afflicting them (scours, respiratory disease, etc.) or the death of the animal.

The gain in body-weight was estimated by measuring each animal's chest girth once a week for the first 6 weeks, again in the 8th week and then in the 12th, 16th, 20th and 24th weeks of their lives.

Vacuum tubes (Venoject®) were used to take a blood sample from the vena jugularis of each calf when it was two or three days old. A Cobas Mira biochemical analyser (La Roche) was used to measure the activity of the GGT, the TSP and the albumin concentration of the serum and an ABC Vet haematological counter was used to determine the number of leucocytes (WBC) in the blood.

The data were statistically processed using version 8 of the SAS/STAT programme. We assessed the statistical parameters – mean value

(x), standard deviation (SD), coefficient of variability (CV) – of the colostrum, blood and serum characteristics that we were investigating. We also determined the correlations between the Ig concentration of the first colostrum and the levels of WBC, TSP, albumin and the activity of GGT.

For the analysis of variance we used the statistical model:

$$Y_{ijklm} = \mu + S_i + H_j + T_k + C_l + e_{ijklm}$$

μ = mean value of the model
S_i = influence of sex (i = 1, 2)
H_j= influence of health status (j = ill, healthy)
T_k= influence of time of first intake of colostrum (c = 0.5... 6.5 hours)
C_l= influence of Ig concentration in first colostrum (l = 20... 145 mg/ml)
e_{ijklm} = accidental error of the model (rest)

Results

The mean chest girth in the first week was 79.37 ± 2.78 cm and changed very little until the calves were four-weeks old. By the fourth week it was 82.24 ± 3.91 cm, then it slowly increased by 2-3 cm per week and was 130.23 ± 6.37 cm by the 24th week.

We compared the gain between the calves that were ill at least once and the healthy calves and determined that the gain in the former group was slightly less than the latter, however, the difference was not statistically significant. The duration of any illness in the calves was usually between one and four days.

The majority of the calves (88.89 %) suckled colostrum within three hours of birth. The activity of GGT was below 200 U/L in six calves and 10 had a TSP concentration that was less than 50 g/L.

The correlations between the monitored parameters of the calves are represented in Table 4. We determined a statistically significant correlation between the Ig concentrations in the colostrums and the amount of TSP and GGT activity in the sera of the calves. There was a statistically significant correlation between the GGT activity and the quantity of TSP and WBC in the blood. There were no other statistically significant correlations established.

With analysis of variance we assessed the influence of sex, health status, interval to the first intake of colostrum and the Ig concentration in colostrum on the levels of GGT activity, TSP and Alb in serum, and WBC in blood and showed the degree of variance. With our statistical model we were able to account for 45.47 % variability in the level of Alb, 37.29 % variability in TSP, 29.65 % variability for WBC and 28.73 % variability for GGT activity. The interval between the first intake of colostrum and its Ig concentration had a statistically significant ($P < 0.05$) influence on the level of GGT activity. The influence of the colostral Ig concentration on the level of TSP amount was also statistically significant ($P < 0.001$). The level of Alb in the serum was influenced by sex, health status and the colostral Ig concentration, whereas the latter was the only source of variability not to influence the level of WBC in the blood.

The calves that fell ill did so within their first 6 weeks; the mean age at the first recognisable sign of disease was 16.3 ± 3.06 days. The Ig content in colostrum had a statistically significant influence on the level of GGT activity ($P = 0.041$), as well as on the quantity of TSP ($P = 0.0008$). It also had slightly less influence on the level of Alb ($P = 0.0601$) and an insignificant influence on the level of WBC ($P = 0.0421$). The most common diseases were diarrhoea (n = 7) and respiratory diseases (n = 5). The faeces samples from calves with diarrhoea indicted the presence of Cryptosporidium and rotavirus.

The interval between birth and the first intake of colostrum had a statistically significant influence on GGT activity ($P = 0.0532$) and the WBC level ($P = 0.0072$), but not on the levels of TSP ($P = 0.9258$) and Alb ($P = 0.9814$).

Discussion

Our research established that the chest girth of calves increased very slowly until they were 4-weeks old and then increased steadily beyond their 24th week (the duration of the study). The calves that fell ill during the study had smaller chest girths than the healthy calves. Caldow et al. (12) established a statistically significant difference in body weight gain ($P < 0.001$) between healthy and sick calves. In our study, the periods of disease were very short, a matter of days, which is why they had such little impact on weight gain.

We established lower levels of GGT activity and TSP in the calves that fell ill, but again, the difference was not statistically significant. Naylor et al.

(11) reported a higher morbidity in calves that had plasma protein concentrations under 60 g/L than in calves with plasma protein concentrations above 60 g/L, which was statistically significant ($P < 0.001$). This implies that plasma protein concentration is as reliable as serum Ig for predicting a calf's susceptibility to disease during its first five weeks of life. Tyler et al. (14) also compared methods for measuring the serum Ig concentration in clinically ill calves and reported that GGT activity above 50 U/L and a TSP level above 55 g/L indicates that there is a sufficient level of Ig in the serum. However, Perino et al. (15) reported that these values were 200 U/L for GGT and 42 g/L for the TSP. Braun et al. (10) recorded higher levels of GGT activity in sera during the first and second day after birth (370 – 5000 U/L). We also recorded a wide variance in the levels of GGT activity.

In this research, we were unable to establish any statistically significant correlation between the levels of GGT activity, TSP and the health of the calves. Other authors also reported similar findings; they were not able to identify any statistically significant correlations between IgG in plasma, mean daily gains and morbidity (3, 12, 16). Other studies have shown that calves with low values of IgG are twice as likely to be frequently ill and/or die than calves with high serum IgG (2, 3). We are of the opinion that the calves that fell ill during the course of our study had adequate levels of Ig in their blood, as only 6 calves had GGT-activity levels below 200 U/L and only 10 had concentrations of TSP below 50 g/L. Therefore, we have attributed the causes for their illnesses to the other factors.

Tyler et al. (1) reported that 39 % of calf mortality was due to inadequate levels of serum Ig, and they attributed the rest to other influences. Factors often linked to outbreaks of disease are associated with inadequate amounts of colostrum, exposure to a potentially virulent pathogen, inadequate hygiene and less than optimal nutritional support. Rajala and Castren (4) were unable to explain the appearance of diarrhoea by only using Ig concentrations in calf serum as an indicator.

The mean Ig concentration in colostrum that we determined in our research was a little higher than the 76.2 mg/ml reported by Rajala and Castren (4). Muller and Ellinger (17) reported that there were differences in the levels of Ig concentration in colostrum between different breeds.

We established that the influence of the Ig concentration in colostrum on the level of GGT activity and TSP was statistically significant, which agrees with the findings of Nocek et al. (18). Rajala and Castren (4) also established a statistically significant correlation between the Ig concentration in colostrum and the Ig level in calf serum ($P < 0.05$), while Erhard et al. (5) also concluded that there was a correlation between the two ($r = 0.37$).

Conclusion

We are of the opinion that the calves used in our study had adequate levels of Ig in their blood, as only 6 calves had a GGT-activity level below 200 U/L and only 10 had concentrations of TSP below 50 g/L.

With our statistical model we were able to account for a 37.29 % variance in the levels of TSP and 28.73 % variance for GGT activity, so we attribute the causes for the recorded illnesses more to other factors (management, exposure to virulent pathogen and nutrition).

The calves that fell ill during this study had lower levels of GGT activity and TSP and gained weight more slowly than the other calves.

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VPLIV KAKOVOSTI KOLOSTRUMA NA ZDRAVSTVENO STANJE IN PRIRAST TELET

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Povzetek: V raziskavo smo vključili 36 telet črno-bele pasme, ki smo jih spremljali od rojstva do starosti 24 tednov. Določali smo koncentracijo Ig v kolostrumu, v serumu pa aktivnost encima gama glutamil–transferaze (GGT), koncentracijo celotnih serumskih beljakovin (CSB) in albuminov (Alb) ter število levkocitov (L) v prvem tednu starosti. Pri teletih smo redno spremljali zdravstveno stanje in prirast s pomočjo merjenja prsnega obsega.

Povprečni prirasti pri obolelih teletih so bili nižji kot pri zdravih, vendar razlika ni bila statistično značilna. Koncentracija Ig v kolostrumu je statistično značilno vplivala na koncentracijo CSB in na aktivnost GGT, ne pa na koncentracijo Alb in število L. Čas prvega pitja kolostruma je statistično značilno vplival na aktivnost GGT in število L, ne pa na vsebnost CSB in količino Alb. Pri bolnih teletih smo ugotovili statistično značilen vpliv samo na število L. Ugotovili smo visoko statistično značilni korelaciji med količino Ig v kolostrumu ter vsebnostjo CSB in aktivnostjo GGT. Aktivnost encima GGT je v statistično značilni korelaciji z vsebnostjo CSB in številom L v krvi.

Ključne besede: teleta; kolostrum; veterinarska medicina; imunologija; zdravstveno stanje; prirast