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IMMUNOGLOBULIN TRANSFER TO CALVES AND HEALTH PROBLEMS IN LARGE BOVINE UNITS ⁽¹⁾

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Résumé

LE TRANSFERT DES IMMUNOGLOBULINES AU VEAU ET LES PROBLEMES SANITAIRES DANS LES GRANDES UNITES BOVINES. — Les taux d'immunoglobulines sériques ont été mesurés chez 215 veaux nés dans 4 fermes. Chaque ferme avait un effectif d'au moins 60 vaches.

Il y avait de grandes variations dans le taux d'immunoglobulines à l'âge de 48 heures. Pour les cas où la quantité de colostrum et la concentration en Ig de ce colostrum étaient connus, on a observé une corrélation entre le taux d'Ig sérique et la quantité d'Ig ingérée. Lorsque seul le taux sérique a été mesuré, on a observé une teneur plus forte chez les veaux nourris à la mamelle par rapport à ceux nourris au seau.

Les taux d'immunoglobulines n'ont pas été en rapport avec l'incidence des diarrhées ou des pneumonies, ni avec la viabilité des veaux, bien que les veaux avec moins de 8 mg/ml d'IgG₁ aient manifesté une fréquence de diarrhée légèrement supérieure.

La concentration en globulines dans le colostrum n'a pas été influencée par la race, la saison, le nombre de vêlages, la durée du tarissement et le niveau alimentaire pendant cette période, mais le moment d'administration du premier repas est très important.

Introduction

Although immunocompetent early *in utero*, the normal newborn calf is born virtually agammaglobulinaemic (reviewed by Fey, 1972; Logan, 1974). The level of serum immunoglobulins acquired from the dam's colostrum by ingestion and subsequent absorption is essential in preventing neonatal

septicaemias. A large consensus has been reached on this point. On the contrary, there seems to be no relation between the level of immunoglobulins established in the blood of the calf at 48 hours when absorption has ended and the subsequent incidence of disease, especially scours (Lomba *et al.*, 1978).

However, there is practical evidence that the incidence of some enteric diseases could be reduced by the continued feeding of colostrum during the first 10 or 15 days post partum. That is the reason why the main

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purposes of our observations were to see whether there was a significant relationship between the level of the passive acquired immunity and the incidence of diseases and whether factors of nutrition or management had any effects on the amounts of maternal immunoglobulins concentrated in the colostrum.

Materials and methods

Observations were made in 4 large bovine units described earlier in detail as Farm II, III, IV, V (Cordiez *et al.*, 1976). Colostrum samples were taken from all cows before suckling or milking. Calves were blood sampled when 48 h. old.

In the colostrum samples, the total protein concentrations were measured by Kjeldahl nitrogen determinations. Whey was then prepared from all the colostrums by incubation with rennet at 37°C followed by centrifugation. The concentrations of the γ globulins were estimated by electrophoresis on cellulose acetate and determination of the soluble nitrogen by the Kjeldahl method. Quantitation of the other constituents was carried out according to the methods described by De Baere and Paquay (1968).

The concentrations of the immunoglobulin classes IgG₁ and IgG₂ in the blood of the calves were estimated by the single radial diffusion technique (Mancini *et al.*, 1965) modified by Williams *et al.* (1975). The γ globulins were measured electrophoretically on cellulose acetate. The other constituents were determined by the classical methods.

Data concerning the effects of the year, breed, level of feeding, calf birth-weight, length of the dry period, and time of milking were recorded.

Results

1. IMMUNOGLOBULIN AND γ GLOBULIN CONCENTRATIONS IN CALF SERUM

The concentrations of IgG₁ in the serum of 215 calves at 48 h. are shown in fig. 1. Their mean value was 12.42 mg/ml with a standard deviation of 9.71.

The mean concentration of the γ globulins in the serum of the same 215 calves was

0.80 g % with a standard deviation of 0.66. As shown in fig. 2, there was a highly significant positive correlation ($r = 0.899$ $P < 0.001$) between the IgG₁ and the γ globulin concentrations in each blood sample.

2. FACTORS AFFECTING THE SERUM GLOBULIN CONCENTRATIONS

Amount of colostrum consumed

Results presented in table 1 show that the serum immunoglobulin or γ globulin concentrations were not related with the amounts of colostrum consumed or with the colostrum immunolactoglobulin concentrations. It is only when taking into account the amounts of γ globulin ingested that a significant positive correlation appeared.

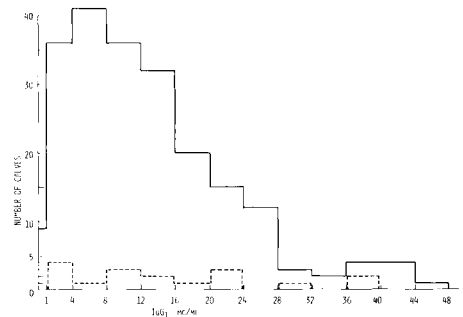


Fig. 1: Immune globulin concentrations in calf serum. Solid line histogram: total. Dotted line histogram: dead calves only.

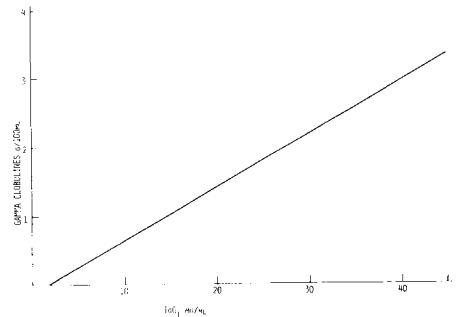


Fig. 2: Relationship between serum immunoglobulin and γ -globulin concentrations at 48 h.

Table 1: Colostrum intakes and serum globulin concentrations at 48 h. post partum.

Characteristics of colostrum	Serum globulin concentration at 48 hours					
	IgG ₁ (mg/ml)			γ globulin (g%)		
	number	r	level of significance	number	r	level of significance
Amounts of colostrum consumed (ml)	26	0.174	—	59	0.150	—
Total immune lactoglobulines absorbed (g)	26	0.475	P < 0.02	59	0.396	P < 0.01
Immune lactoglobulin concentration in colostrum	92	0.087	—	155	0.179	—

The relation between the amount of globulin presented and the amount of globulin absorbed is expressed by the equation

$$y = 4.91 + 0.034 x$$

in which «y» is the IgG₁ concentration in the calf serum at 48 h. and «x» is equal to the amount of immunolactoglobulin presented.

Bucket-fed or suckling

Table 2 shows that calves allowed to obtain their colostrum by suckling their dam attained better serum globulin concentrations than did bucket-fed calves.

Breed and birth-weight

As shown previously (Lomba *et al.*, 1978), there was no noticeable influence of factors such as breed, birth-weight, timing of the first feed or farm.

Table 2: Serum globulin concentrations in suckled and bucket-fed calves.

IgG ₁	Bucket-fed calves		Suckled calves	
	Number	%	Number	%
0-8	44	52.4	42	32
8-16	18	21.4	50	38
16	22	26.4	39	30
Total	84	100.0	131	100.0

$\chi^2=9.987.$ P=0.05.

3. RELATIONSHIP BETWEEN GAMMAGLOBULIN LEVEL IN SERUM AND DISEASE

3.1. *Diarrhoeas*

In the study presented, involving 215 calves, 53 suffered from diarrhoea and 16 of them died. The distribution of the healthy calves and of the diarrhoeic ones according to their serum globulin level at 48 h. is given in table 3. This table shows that there is no relation between the blood level of IgG₁ and a higher subsequent incidence of neonatal diarrhoeas. However, 49% of the sick calves had a gammaglobulin level below the lower limit of 8 mg IgG₁/ml and could be regarded as hypogammaglobulinaemic.

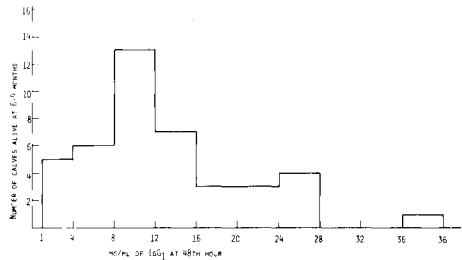


Fig. 3: Serum globulin concentrations at 48 h. of the calves still present in the farms at 6-9 months.

Table 3: Gammaglobulin concentrations at 48 hours in healthy and sick calves.

Classes of calves	IgG ₁ , mg/ml				Total
	0-8	8-16	12-24	24	
Scouring	20 (12)	7 (2)	6 (3)	8 (3)	41 (20)
Healthy	66 (31)	61 (16)	29 (11)	18 (15)	174 (63)
Total	86 (43)	68 (18)	35 (14)	26 (8)	215 (83)

()=bucket-fed calves; $\chi^2=2.84$ non significant.
 $\chi^2=6.75$ non significant.

3.2. Viability

Of the 215 calves, 43 were still on the farm at 6-9 months of age. The distribution of these calves according to their serum IgG₁ level at 48 h. (fig. 3) is normal. This implies that a prediction of the calves ability to survive on their serum globulin level at 48 h. is still impossible.

3.3. Pneumonia

There was no significant relationship between the incidence of pneumonia and the serum globulin level at 48 h.

4. DIFFERENCES IN GLOBULIN CONCENTRATIONS IN COLOSTRUM

The globulin concentrations in colostrum are given in table 4 for the different farms.

The effect of the season of the year and of the number of calving is measured. The mean of the colostrum immune lactoglobulin concentrations, which are normally distributed, was 6.30 g/100 ml of total colostrum with a standard deviation of 3.11.

The differences in concentration between the farms were highly significant but there was no seasonal influence.

5. FACTORS AFFECTING THE GLOBULIN CONCENTRATIONS IN COLOSTRUM

The search for the factors responsible for the variations of the colostrum immune lactoglobulin concentrations prompted us to measure the other constituents of the colostrum and to appreciate the influence of some components of the management.

Table 4: Immune lactoglobulin concentrations (g%) in colostrum (Means \pm S.D.).

Farm	Heifers		Older cows		No.	Whole herd
	No.	No.	No.	No.		
	summer	winter	summer	winter		
	4	3	8	45	60	
II	6.84 \pm 1.88	4.83 \pm 1.10	5.67 \pm 2.37	6.06 \pm 2.41	6.00 \pm 2.31	
	23	7	28	35	93	
III	4.04 \pm 2.49	4.47 \pm 1.65	4.37 \pm 2.77	5.16 \pm 2.97	4.60 \pm 2.72	
	9	9	25	30	73	
IV	8.46 \pm 2.25	9.66 \pm 2.63	7.09 \pm 3.01	7.47 \pm 2.70	7.73 \pm 2.83	
	4	6	6	14	30	
V	11.30 \pm 2.60	8.66 \pm 5.44	7.20 \pm 1.40	8.68 \pm 2.54	8.73 \pm 3.23	

Table 5: Relationship between the immune lactoglobulins and other constituents in colostrum.

Constituent	number of colostrums	mean concentration and standard deviation		correlation coefficient and level of significance	
immune lactoglobulins g/100 ml	262	6.30	3.11	—	—
total prot. g/100 ml	262	13.56	4.85	0.844	P < 0.001
NPN g/100 ml	63	0.10	0.05	0.190	—
carotene μ g/100 ml	262	278.00	213.00	-0.107	—
vit. A μ g/100 ml	262	269.00	222.00	0.338	P < 0.001
calcium mg/l	262	2029.00	612.00	0.416	P < 0.001
phosphorus mg/l	262	1668.00	444.00	0.320	P < 0.001
magnesium mg/l	262	300.00	105.00	0.625	P < 0.001
sodium mg/l	262	751.00	297.00	0.027	—
potassium mg/l	262	1454.00	315.00	0.031	—
soluble proteins g/100 ml	262	811.00	3.54	0.988	P < 0.001
casein g/100 ml	260	5.65	1.65	0.509	P < 0.001
fat g/100 ml	165	4.60	2.71	0.025	—

5.1. Concentrations of other constituents in colostrum

Table 5 shows, for all the constituents analysed in the colostrum, their mean concentration with the standard deviation and their correlation coefficient and level of significance with the immune lactoglobulins. There is a highly significant positive correlation with the total protein, vitamin A and the ions calcium, phosphorus and magnesium.

5.2. Factors of the management

There was no significant relationship between the immune lactoglobulin concentrations in colostrum and factors such as:

— the breed of the cows, even if the highest concentrations were recorded in farm V (Belgian Blue White breed). Indeed, although they were significantly higher ($P < 0.001$) than in farms II and III, this was certainly not the case with farm IV, and each of these 3 farms II, III, IV were raising dairy cows of the same breed (Friesian black-pie).

— The number of calvings, at least when comparing the colostrum concentrations of 65 heifers (globulin mean concentration 6.56 g/100 ml with a standard deviation of 3.64) and of 191 older cows (globulin mean

concentration 6.22 g/100 ml with a standard deviation of 2.92).

— The length of the dry period which ranged from 10 to 120 days with a mean of 66 days.

— The total milk production in the previous year.

— The level of feeding during the dry period, despite the wide range in the feeding levels of crude protein, energy, calcium, phosphorus and magnesium.

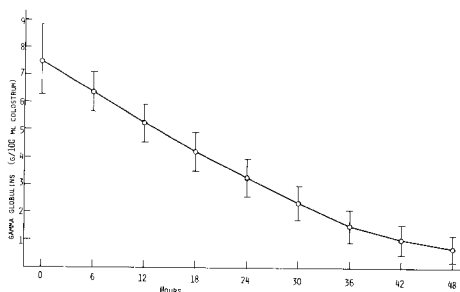


Fig. 4: Relationship between the immune lactoglobulin concentrations in colostrum of normally milked quarters with the times of milking post partum.

On the other hand, the time elapsed between birth and the first milking or suckling is of prime importance. Figure 4 shows how quickly and regularly the γ -globulin concentration of the colostrum fell soon after parturition. Since this study was done with normally milked cows, we repeated the measurements on unmilked cows. Only a small amount of colostrum was obtained (Fig. 5) but the rate of dilution of the colostrum proved to be almost exactly the same as in emptied quarters.

Results obtained during this experiment showed also that, as far as suckling calves are concerned :

— the amount of colostrum ingested on the first feed was much higher than usually thought. It was not significantly different from one calf to another and the mean intake was 2 kg ;

— but the first suckling took place much earlier with the Friesian calves (2-3 h. post partum) than with the calves of the Belgian Blue White breed (10-12 h. post partum).

Discussion

The highly significant positive correlation between the immunoglobulin and the globulin levels in the serum of the calves at 48 h. ($r = 0.899$ $P < 0.001$) and between the immunolactoglobulin and the total pro-

tein concentrations in colostrum ($r = 0.844$ $P < 0.001$), added to the strong relation between γ globulin in the blood of the calves and in the colostrum (Table 5), indicates, as observed by Halliday *et al.* (1978), that a fairly good estimation of the quality of a colostrum as regards the calf itself is quite possible by measuring the total protein content or the γ globulin concentration in colostrum by methods which are relatively simple rather than by more sophisticated methods such as immunoelectrophoresis.

The serum immunoglobulin levels at 48 h. were significantly correlated with the quantity of immune lactoglobulin fed. This means that one has always to consider the volume of colostrum ingested and the immune lactoglobulin content of that colostrum (Selman *et al.*, 1971). In our field conditions, both the colostrum intakes and the globulin concentrations varied greatly. It was shown also that calves which suckled their dam attained higher serum globulin levels than did bucket-fed calves (Table 2). But there was no significant influence of the farm, of the breed, provided that the first time of feeding was the same, and of the birth-weight.

In each farm, as many as 40% of the calves had a serum immune globulin content below 8 mg/ml and could be regarded as hypogammaglobulinaemic (Penhale *et al.*, 1973 ; Williams *et al.*, 1975) but like Hurvell and Fey (1970) or Halliday *et al.* (1978) we found no significant relationship between the serum globulin concentrations and the incidence of diseases such as enteritis or pneumonia. In the same manner, the prediction of the viability of the calves on the basis of their serum globulin level at 48 h. appeared impossible (Fig. 3).

However, Logan and Penhale (1971 a, b) demonstrated that colostral immunoglobulins, as well as being active in the serum and protecting against septicaemia, have a local protective action within the small intestine. Thus, for a calf to survive, intestinal immunoglobulins must be present in adequate quantities. Consequently it is necessary to ensure that the newborn calf receives adequate amounts of immune lactoglobulins of good quality early in life.

From this point of view, the study presented shows that :

1° There is a highly significant positive

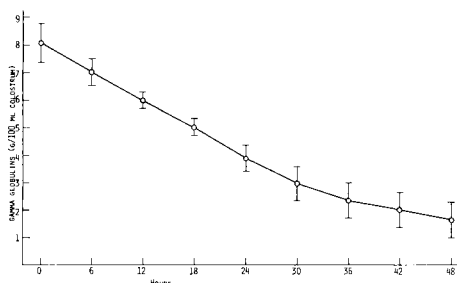


Fig. 5: Relationship between the immune lactoglobulin concentrations in colostrum of non-milked quarters with the time of milking post partum.

correlation between on the one hand the immune lactoglobulins and on the other hand the total protein content, vitamin A, and the ions calcium, phosphorus and magnesium. This could be of practical importance since it was shown by Cabello and Michel (1977) that calves which remained healthy had from birth higher serum levels of globulin, calcium phosphorus and magnesium than calves which suffered from diarrhoea but survived.

2° There was no significant influence of factors such as the breed, the season, the number of calvings, the length of the dry period, the level of feeding during this period and the previous total milk production.

3° There were not many observations on colostrum concentration but the rapid fall in the immunoglobulin content of the mammary secretion was clearly established (Fig. 4). Moreover, it was shown that contrary to what is generally thought, the

colostrum became diluted at the same rate in non-milked quarters as in emptied quarters (Fig. 5). Porter (1972) observed a six-fold reduction in the total protein content in 48 hours. It appeared that under our conditions, the globulin content was reduced to 80, 70, 40 and 10% respectively 6, 12, 24 and 48 hours post partum.

The results of the above investigation provide enough reasons for the very varied serum immune globulin concentrations in our calves. Firstly, the time of the first suckling or the first milking varied very much from one case to another; secondly, the amounts of colostrum consumed by suckling calves and bucket-fed calves were never the same; thirdly, although the globulin concentrations were lower than expected in colostrum collected within a few minutes post partum, there were differences in the protein, vitamin A and ion contents and the effects of these differences need to be considered.

Summary

The serum immunoglobulin levels were studied in 215 calves born on 4 farms. Each farm had at least 60 cows.

There was a great variation in the immunoglobulin levels at 48 hours. In those cases where the quantity and Ig concentration of colostrum was measured it was found that the serum Ig level was correlated with the total amount of Ig ingested. Where only the serum level was measured it was found that suckled calves had higher levels than bucket-fed calves.

Immunoglobulin levels were not correlated with the incidence of diarrhoea or pneumonia nor with the viability of calves although calves with less than 8 mg/ml IgG₁ showed a slightly higher incidence of diarrhoea.

The globulin concentrations in colostrum were not influenced by the breed, the season, the number of calvings, the length of the dry period and the level of feeding during this period but the time of the first feeding or milking proved to be of prime importance.

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