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FACTORS AFFECTING LEVELS OF PASSIVE IMMUNITY IN DAIRY CALVES

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SUMMARY

Pre-suckling sera of 16 calves contained low levels of IgG_1, IgG_2 and IgM but no detectable IgA. Forty-eight-hour serum levels of Ig were determined for 128 dairy calves which had been observed from birth for 6 h. Levels of all classes of Ig were related to the latency to first suckling, and decreased in relation to parity of the dam and month of calving. No calf suckling unaided within 6 h of birth or assisted to suckle soon after this time failed to achieve adequate levels of Ig. With these comparatively high Ig levels there was no correlation between the level of any class of Ig and daily liveweight gain to weaning.

INTRODUCTION

Calves are born with very low levels of immunity and, during the first few weeks of life, are dependent on immunoglobulin absorbed from colostrum (Husband, Brandon & Lascelles, 1972; Jensen, 1978). Animals which fail to attain adequate levels of passive immunity are much more susceptible to neonatal disease and mortality (McEwan, Fisher & Selman, 1970b; Kilkenny, 1975; Fallon, 1978). Surveys have shown that as many as 50% of calves may be hypogammaglobulinaemic (Kilkenny, 1975; Fallon 1978). Some of the observed variations in levels of calf immunity can be accounted for by differences in management (Selman, 1973). However, the variation is great even within a herd (Randall, 1978) and this has led to investigations to determine the best system of management of newborn calves in order to ensure optimum immunity levels (Randall, 1978).

This study of a large number of calves on a commercial dairy farm examines some of the reasons for variation in passive immunity levels between calves and the effects of different systems of management.

MATERIALS AND METHODS

The calves in this study were born in the autumn and winter of 1977 and 1978 at Sonning Farm, University of Reading, where a herd of about 350 Friesian cows was kept. Several weeks prior to calving cows were transferred to a covered yard. When calving appeared imminent some animals were moved to individual calving pens, whilst others gave birth within the pre-calving group.

Calves were observed continuously from birth for the first 6 h *post partum*. Animals failing to suckle within this period were usually put to the teat as soon as possible afterwards. Calves remained with their dam for a period ranging from 12 to 48 h before being transferred to the rearing unit. They were weighed on removal from their dam and at weaning.

As close as possible to 48 h *post partum* (mean 48·2 h, S.E. 4·1 h) a blood sample was taken by jugular venipuncture into an evacuated tube. In addition 16 calves not involved in the behavioural study were blood sampled immediately after birth, when it was known that suckling had not occurred. The samples were allowed to clot at room temperature and the serum separated off. This was subsequently analysed for IgG_1, IgG_2, IgA and IgM by single radial immunodiffusion (Mancini, Carbonara & Heremans, 1965). The total number of 48-h samples was 69 in 1977 and 59 in 1978. IgG_2 analyses for the 1978 samples were not done as insufficient antiserum was available.

The data were not normally distributed so the Mann-Whitney U test was used for all comparisons between groups and the Spearman Rank test for all correlations.

TABLE I

THE SERUM Ig LEVELS OF CALVES PRIOR TO SUCKLING

Calf no.	*Pre-suckling serum concentration mg/ml*			
	IgG_1	*IgG_2*	*IgA*	*IgM*
2872	0·50	ND	ND	0·10
2875	ND	ND	ND	ND
2887	ND	ND	ND	ND
2889	ND	ND	ND	ND
2891	1·35	1·00	ND	0·50
2894	0·50	ND	ND	0·10
2895	ND	ND	ND	ND
2897	2·00	ND	ND	0·18
2931	ND	ND	ND	0·10
2950	3·50	2·00	ND	0·13
2953	ND	ND	ND	ND
2954	ND	ND	ND	0·10
2955	1·50	0·14	ND	0·13
2957	1·35	0·12	ND	0·10
2961	1·00	ND	ND	ND
2962	ND	ND	ND	ND

ND none detectable.

RESULTS

Pre-suckling serum Ig levels

The serum Ig levels of 16 calves sampled immediately after birth and prior to any intake of colostrum are shown in Table I. IgA was not detectable in the serum of any of the calves sampled and six calves (38%) also had no detectable IgG_1, IgG_2 or IgM. IgG_2 was not detectable in 12 calves (75%), IgG_1 in eight calves (50%) and IgM in seven calves (44%). No calf had more than 3·50 mg/ml of IgG_1, 2·00 mg/ml of IgG_2 or 0·50 mg/ml of IgM.

Factors affecting 48-h Ig levels

There were no differences in Ig levels between the two years so the data have been combined.

Fig. 1 shows the distribution of serum Ig levels of the calves in this study for each of the four sub-classes of Ig. The range of values was very great in each case. Calves which suckled within 6 h of birth achieved higher levels of all Igs than calves which failed to suckle within this period (Table II). Of all the calves which failed to suckle, those that were subsequently assisted to suckle achieved higher levels of IgG_1 than those left undisturbed with their dams. However, the procedure adopted had no effect on the levels of any of the other sub-classes of Ig.

TABLE II

THE 48-H SERUM Ig LEVELS OF CALVES IN RELATION TO POST-NATAL MANAGEMENT, MONTH OF BIRTH AND PARITY OF THEIR DAM

	No. of calves		*Mean serum concentration mg/ml**			
	IgG_1, IgA, IgM	*IgG_2*	*IgG_1*	*IgG_2*	*IgA*	*IgM*
Post-natal management						
Suckling within 6 h	90	46	$55·21^a$	$0·81^a$	$2·28^a$	$2·59^a$
Assisted to suckle after 6 h	29	20	$31·07^b$	$0·61^b$	$1·50^b$	$1·23^b$
No suckling nor assistance	8	2	$7·07^c$	0·75	1·91	$1·12^b$
Month of birth						
August & September	45	21	$50·44^a$	0·78	2·33	$2·34^a$
October	41	25	47·42	$0·82^a$	2·19	$2·44^a$
November	26	14	46·38	0·70	1·88	1·92
December & January	16	9	$34·60^b$	$0·59^b$	1·72	$1·57^b$
Parity of the dam						
1	51	25	$55·00^a$	0·81	2·25	$2·80^a$
2	32	17	$42·69^b$	0·76	1·81	$1·75^b$
3	18	10	$38·70^b$	0·66	2·08	$1·67^b$
4+	27	17	$40·74^b$	0·72	2·10	$1·90^b$

* Within each section values with different superscripts are significantly different at the 5% level.

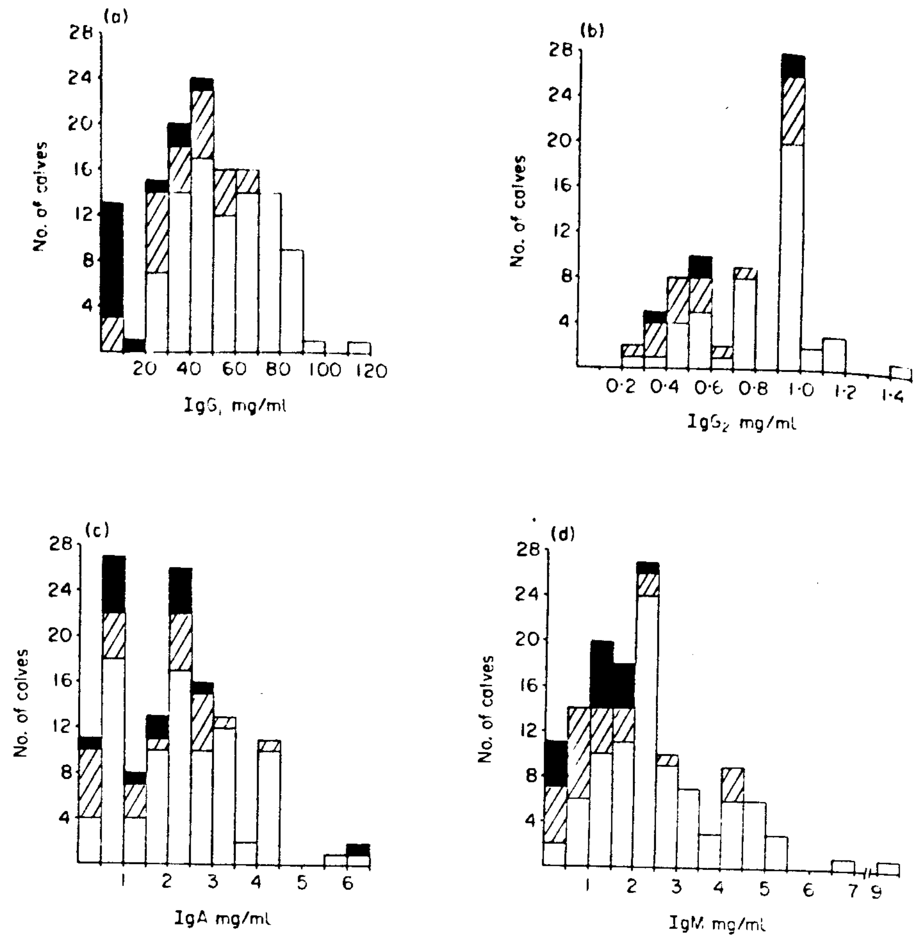

Fig. 1. The 48-h serum levels of a) IgG_1 of 127 dairy calves, b) IgG_2 of 88 dairy calves, c) IgA of 127 dairy calves and d) IgM of 127 dairy calves. □ suckling within 6 h, ▨ assisted after 6 h, ■ no suckling nor assistance.

The levels of IgG_1, IgG_2 and IgM decreased as the calving season progressed and there were indications of a similar tendency in levels of IgA (Table II).

The serum levels of IgG_1 and IgM of calves decreased with the parity of their dam but this factor had no apparent effect on levels of IgG_2 or IgA (Table II). There were no differences in serum Ig levels between calves born in single pens and calves born within a group of animals in a covered yard.

Levels of all sub-classes of Ig were strongly correlated with the length of delay between birth and first suckling ($r_s = -0{\cdot}54$, $-0{\cdot}40$, $-0{\cdot}36$ and $-0{\cdot}51$ for IgG_1, IgG_2, IgA and IgM respectively, $P<0{\cdot}001$ in all cases).

There was no relationship between the age at which the calves were removed from their dams and levels of any of the sub-classes of Ig.

Relationship between the different sub-classes of Ig

There were strong positive correlations between the serum levels of the different sub-classes of Ig. The strongest correlation was between IgG_1 and IgM (r_s = 0·75, $P<0·001$), but correlations between IgG_1 and IgG_2 (r_s = 0·52, $P<0·001$), IgG_1 and IgA (r_s = 0·59, $P<0·001$), and IgA and IgM (r_s = 0·61, $P<0·001$) were also high. Correlations between IgG_2 and IgM (r_s = 0·43, $P<0·001$), and IgG_2 and IgA (r_s = 0·39, $P<0·001$) were weaker.

The relationship between Ig levels and daily liveweight gain

There were no correlations between serum levels of any of the sub-classes of Ig and daily liveweight gain to weaning.

DISCUSSION

The results of this study show the wide variation in levels of passive immunity which occurs amongst calves under the same conditions of management and indicate some of the reasons for this.

At birth serum Ig levels are low and differences between calves are minor. No calf was found to have IgA in the serum prior to suckling, in agreement with previous reports (Penhale *et al.*, 1973; Logan *et al.*, 1978). However, there have been reports of the presence of IgA in a small minority of animals (Husband *et al.*, 1972) and in very small quantities (Jensen, 1978). The low levels of IgG_1, IgG_2 and IgM observed in some calves prior to suckling are comparable with those previously recorded (Klaus, Bennett & Jones, 1969; Husband *et al.*, 1972; Jensen, 1978). One calf did have quite high serum levels of IgG_1 and IgG_2, despite the certainty that it was sampled prior to any intake of colostrum. It has previously been noted that some calves have abnormally high levels of Ig in pre-suckling blood samples (Husband *et al.*, 1972; Penhale *et al.*, 1973; Jensen, 1978) which could result from passage of Ig across a damaged placenta or from autosynthesis by the immunologically competent foetal calf (Osburn *et al.*, 1974).

No calf known to have obtained ample colostrum within the first 7 h of life failed to absorb Ig. This supports the view of Kruse (1970b) that no young calf is unable to absorb Ig and that the high incidence of hypogammaglobulinaemia observed in surveys is due to too long a delay before ingesting colostrum or to ingestion of an inadequate amount of Ig. There is no evidence for the theory proposed by Fey (1971) that some young calves are physiologically incapable of absorbing Ig. This contrasts with some previous studies in which calves known to have received colostrum early in life were subsequently found to be hypogammaglobulinaemic (Klaus *et al.*, 1969).

The 48-h levels of IgG_2, IgA and IgM recorded are generally comparable with those previously observed in the sera of dairy calves suckling their dams (Klaus *et al.*, 1969; Penhale *et al.*, 1973). IgG_1 is the predominant Ig present in colostrum (Brandon, Watson & Lascelles, 1971), hence calves should have high serum levels. Levels of IgG_1 in many calves were higher than those previously reported, but the population sampled was atypical since nearly all animals received ample colostrum within 7 h of birth and for the next 12 h at least.

The strong correlations between the 48-h serum levels of the different sub-classes of Ig have also been noted previously. In all cases the strongest correlation was between IgG_1 and IgM. Thus the zinc sulphate turbidity test (McEwan *et al.*, 1970a), which estimates total Ig and therefore reflects principally IgG_1 concentrations, is a good indicator of the levels of all sub-classes of Ig.

The major factor affecting the level of Ig attained by calves in this study was the delay before suckling. The importance of the length of delay between birth and first intake of colostrum in influencing levels of passive immunity has been noted in both suckling (Selman, McEwan & Fisher, 1970) and bucket-fed calves (Kruse, 1970b; Selman, 1973). This effect is attributable to two different factors, the most important being the progressive decrease in the ability of the calf to absorb Ig which begins at birth (Kruse, 1970b). However, it has also been shown that the concentration of Ig in the colostrum decreases with time after calving, even when no withdrawal of colostrum takes place (Kruse, 1970a; Lomba *et al.*, 1978).

In this study it was found that the Ig levels of calves decreased as the calving season progressed. A similar trend in Ig levels related to month of calving was reported by McEwan *et al.* (1970b) in a survey of market calves in Scotland. Smith, O'Neil & Simmons (1967) failed to find any such trends in English calves, although seasonal effects have subsequently been observed in other English studies (Randall, 1978). It has been postulated that such seasonal effects are related to seasonal differences in the housing and management of the cattle (Selman, 1973), since Ig absorption is not depressed by cold (Cabello & Levieux, 1978) and there is no seasonal variation in colostral Ig concentration (Kruse, 1970a; Lomba *et al.*, 1978). However in the present study the observed seasonal effect on Ig levels is related not to differences in management but to a similar trend in suckling latencies (Edwards, 1981). As the season progressed and air temperatures decreased it was observed that calves had increased latencies to standing and showed less intense teat-seeking.

The seasonal trend was also partially attributable to the fact that the proportion of older cows calving increased as the season progressed. This is the normal pattern in autumn-calving herds. The lower Ig levels in calves of older cows can again be attributed to differences in suckling latencies, since suckling is delayed as a result of poorer udder conformation in these animals (Edwards, 1981).

Calves suckling within 6 h of birth attained higher levels of all sub-classes of Ig than calves failing to suckle. However, most calves which were assisted to suckle soon after this period still attained levels of Ig well in excess of those considered adequate to provide protection against neonatal disease. It thus appears that assisting calves to suckle at any time during the first 7 h *post partum* will ensure that they attain a good immunity status. Calves which failed to suckle within 6 h of birth and were not subsequently assisted to suckle had much lower levels of IgG_1, the predominant Ig in colostrum, but levels of the other sub-classes of Ig were no lower. It may be that, although ability to absorb Ig does decrease from birth, the first 6 h do not constitute such a critical period as previously suggested provided that ample colostrum is obtained relatively soon after this time. Beef calves removed from their dams at birth and not returned until 12 h *post partum* attained 48-h serum Ig levels equal to those of calves left undisturbed with their dam (Waldhalm, 1971).

No relationship was found in this study between daily liveweight gain to weaning and serum levels of any of the sub-classes of Ig. This has previously been the case in a number of studies of home-reared (Randall, 1978) and purchased calves (Fallon, 1978) and is even less surprising in the present study since management procedures were such that nearly all calves had Ig levels well above those considered to be adequate for protection against neonatal disease. However, the Ig status of calves is of great importance in disease prevention, especially when calves are moved from their farm of birth (Kilkenny, 1975; Fallon, 1978).

No relationship was observed between the age at which the calf was separated from its dam, provided that this was at least 12 h, and its serum Ig level. Therefore, the results of this study suggest that a good management policy would be to assist all calves to suckle as soon as they are first seen and to leave them with their dam for a further 12 h before removing them at a convenient time.

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