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THE ABSORPTION OF COLOSTRAL GLOBULINS BY NEWBORN CALVES

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SUMMARY

It is now widely recognized that the absorption of colostrum globulins is not an inevitable sequel to the ingestion of colostrum by newborn calves.

In this paper, factors known to affect the absorption-efficiency of newborn dairy calves are discussed, together with the effect of variations in serum immune globulin concentrations on the incidence of neonatal morbidity and mortality.

INTRODUCTION

For at least 50 years, it has been recognized that a calf which has consumed bovine colostrum within a short time of birth is more likely to survive the neonatal period than is a colostrum-deprived animal (SMITH and LITTLE, 1922). This protective property of colostrum is now known to be a result of the fact that for a limited period after birth, a calf's intestinal epithelial cells are able to absorb intact macromolecules (PIERCE, 1962). By this means, immune globulins (present in high concentrations in most samples of bovine colostrum obtained at parturition) are acquired; the calf thereby receiving a degree of resistance at least against the two commonest causes of morbidity and/or mortality in young calves, colisepticaemia and enteric colibacillosis (GAY, 1965).

Unfortunately, the absorption of immune globulins is not an inevitable sequel to the early consumption of colostrum. There is now ample evidence to show that many dairy calves which have been fed colostrum by traditionally acceptable methods have subsequently proved to be agamma or hypogammoglobulinaemic (FEY and MARGADANT, 1961; GAY ANDERSON, FISHER and McEVAN, 1965; McEVAN, FISHER and SELMAN, 1970; SELMAN, de la FUENTE, FISHER and McEVAN, 1971 c). Studies

on large number of dairy calves in the West of Scotland have shown that individual variations in the serum immune globulin concentrations of young, colostrum-fed calves exert a very marked effect on mortality rates and patterns (GAY *et al.*, 1965; McEWAN *et al.*, 1970; SELMAN *et al.*, 1971 *c*). In fact, it is now becoming increasingly obvious that many of the long recognized epidemiological features of neonatal disease in dairy calves in Great Britain can be explained in terms of variations in the degree of passively (*i. e.* from colostrum) acquired resistance.

A. — *Factors affecting the globulin-absorptive efficiency of newborn calves*

Wide individual variations have been shown to exist in the serum immune globulin concentrations of young, colostrum-fed dairy calves (see above) and those with high concentrations usually survive under conditions which commonly prove fatal to agamma and hypo-gammaglobulinaemic animals (McEWAN *et al.*, 1970). No evidence has yet been produced to show that certain individual calves are congenitally incapable of immune globulin absorption and increasingly, it becomes clear that individual variations in serum immune globulin concentrations of colostrum-fed calves are due to managerial factors. Basically, the three major factors affecting absorptive efficiency are as follows :

1. *The age at which colostrum is first ingested.*

Early work in calves and related species indicated that the period during which macromolecular absorption was possible was limited to the first 24-48 hours *post partum*

TABLE I

The effect of feeding colostrum at varying times post partum to thirty newborn Ayrshire calves

Effets du retard de l'ingestion de colostrum chez 30 veaux *Ayrshire* nouveau-nés

Calves	N°	Birthweights (kg) Mean ± SD	Volume of Colostrum* fed (ml) Mean ± SD	Time Colostrum fed (hours) <i>post partum</i>	48 hours serum concentrations of absorbed Immune Lactoglobulin (ZST units) Mean ± SD	Significance
Group I	(10)	31.4 ± 4.4	1 725 ± 241.4	1	23.0 ± 6.5	P = > 0.05
Group II	(10)	33.9 ± 6.4	1 863 ± 350.0	5	17.7 ± 4.1	P = > 0.01
Group III	(10)	33.6 ± 3.5	1 852 ± 185.5	9	12.5 ± 2.2	

* All calves received colostrum from a single pool (mean immune lactoglobulin whey concentration (12 samples) = 8.66 ± 0.6 g/100 ml) and fed at the rate of 55 ml/kg (birthweight) as one single feed at the times specified (SELMAN, 1969).

* *Tous les veaux ont reçu le colostrum provenant d'un pool unique* (concentration moyenne de 12 échantillons en immuno-lactoglobulines du sérum colostrale = 8,66 ± 0,6 g/100 ml). *Les animaux ont reçu un seul repas, aux temps indiqués, de 55 ml/kg (poids à la naissance)* (SELMAN, 1969).

partum (COMLINE, ROBERTS and TITCHEN, 1951 ; PIERCE, 1961). Later, studies into the rate, or efficiency of absorption within this period (KAECKENBEECK, COLINET and SCHOENAERS, 1961) revealed that this decreased rapidly after the first 12 hours of life. Recently, it has been shown the absorptive efficiency of newborn calves decreases from birth (KRUSE, 1967 ; SELMAN, 1969). This has been shown to occur under conditions of natural suckling (SELMAN *et al.*, 1970 *c*) and under carefully controlled laboratory conditions involving the feeding of pooled bovine colostrum to *Ayrshire* calves at a fixed rate and set times *post partum* (SELMAN, 1969). The results of this latter study are set out in table 1.

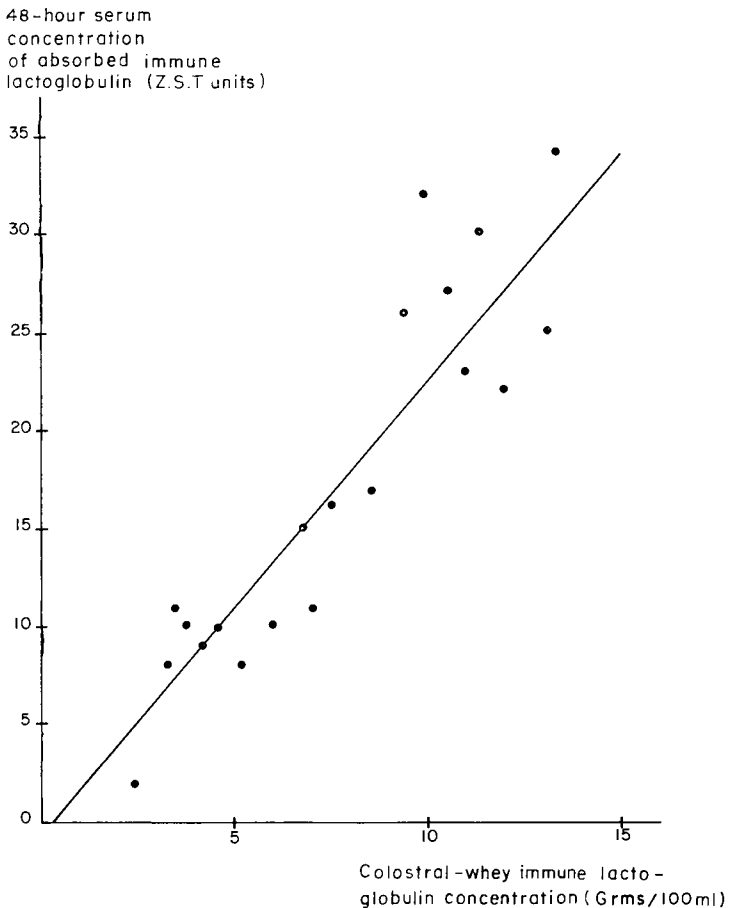


FIG. 1. — The relationship between the colostrum-whey immune lactoglobulin concentration of 20 different samples of bovine colostrum and the 48-hour serum concentrations of absorbed immune lactoglobulin of 20 newborn *Ayrshire* calves fed those samples under standardised conditions.

FIG. 1. — Relation entre la concentration en immunolactoglobuline du sérum colostrum des 20 échantillons différents de colostrum bovin et les concentrations, dans le sérum sanguin à 48 heures, des immunolactoglobulines absorbées chez 20 veaux nouveaux-nés de race *Ayrshire* ayant reçu ces échantillons dans des conditions standardisées.

2. *The amount of globulin ingested.*

Under controlled laboratory conditions (see above) a highly significant relationship has been found to occur between the amount of globulin presented to, and the amount absorbed by, a newborn calf (fig. 1).

3. *The effect of the presence of the dam.*

Calves left with their dams attain significantly higher serum immune globulin concentrations than do calves removed from their dams shortly after birth, even when allowance is made for variations in time of feeding and globulin intake. This phenomenon has been investigated under conditions of natural suckling (SELMAN *et al.*, 1971 a) and under much more controlled laboratory conditions (SELMAN *et*

TABLE 2

The effect of dam presence on the absorption of immuno lactoglobulin by twenty newborn Ayrshire calves

Effet de la présence de la mère sur l'absorption des immunoglobulines chez vingt veaux nouveau-nés de race Ayrshire

Calves	Nº	Birthweights (lbs) Mean \pm SM	Vol. of Colostrum* consumed (ml) Mean \pm SD	48-hours serum concentrations of absorbed immune Lactoglobulin (ZST units) Mean \pm SD	Significance
Group I (non-mothered)	(10)	31.1 \pm 4.5	1 713 \pm 248	10.3 \pm 2.4	P = < 0.001
Group II (mothered)	(10)	32.2 \pm 4.4	1 776 \pm 220	17.7 \pm 3.1	

* All calves received colostrum from a single pool (mean immune lactoglobulin whey concentration (16 samples) = 6.8 \pm 0.3 g/100 ml) and fed at the rate of 55 ml/kg (birthweight) divided into three equal volumes and fed at 1,5 and 9 hours *post partum* (SELMAN *et al.*, 1971 b).

* *Tous les veaux ont reçu le colostrum provenant d'un pool unique* (concentration moyenne en immunoglobulines (16 échantillons) = 6,8 \pm 0,3 g/100 ml), *distribué à raison de 55 ml/kg* (poids à la naissance), *après division en 3 volumes égaux, 1,5 et 9 h après la naissance.* (SELMAN *et al.*, 1971 b).

al., 1971 b) and the results of this latter study are presented in table 2. At present, the reason for these differences are not known, although a similar phenomenon has been noted in rats (HALLIDAY, 1959) and puppies (FILKINS and GILLETTE, 1966).

B. — *Epidemiological considerations*

Investigations into neonatal calf disease have confirmed that this is one of the major problems confronting the cattle industry of Great Britain (LEECH, MACRAE and MENZIES, 1968). Certain, well-defined epidemiological features have been régu-

larly highlighted by such surveys and the relationship between the most important of these and the degree of colostrum — derived protection attained by newborn calves is discussed below :

1. *The method by which colostrum is first obtained by a newborn calf.*

Convincing evidence now exists to show that dairy calves which first obtain colostrum by suckling their dams are less susceptible to neonatal death than are similar calves which first obtain colostrum from a bucket (WITHERS, 1952-1953 ; LEECH *et al.*, 1968). The main reason would appear to be that calves which first obtain colostrum by suckling are more likely to attain higher serum immune globulin concentrations than are bucket-fed calves (SMITH, O'NEIL *et al.* SIMMONDS, 1967 ; SELMAN *et al.*, 1971 *c*). Reasons for this have been defined and it is clear that the former calves are at an advantage because they usually ingest colostrum sooner (SELMAN *et al.*, 1970 *b*) and in greater quantity (SELMAN *et al.*, 1971 *a*) than those fed colostrum by bucket. In addition, they are usually subject to uninterrupted and prolonged mothering by their dams (SELMAN *et al.*, 1970 *a*).

2. *The effect of season.*

In Britain, the period of highest neonatal calf mortality is during the period between January and April (WITHERS, 1952-1953 ; LEECH *et al.*, 1968). Surveys carried out in the West of Scotland (GAT *et al.*, 1965 *b* ; McEWAN *et al.*, 1970 ; SELMAN *et al.*, 1971 *c*) have shown that there is, in addition, a marked seasonal variation in the serum immune globulin concentrations of colostrum-fed dairy calves with very low mean concentrations being present during the period between October and April (*i. e.* the winter-housing period). Thus, the period of highest mortality occurs during the latter half of the winter-housing period when the vast majority of calves are not only highly susceptible to neonatal disease (McEWAN *et al.*, 1970) but are also probably being subjected to a far greater degree of pathogenic challenge (ROY, PALMER, SHILLAM, INGRAM and WOOD, 1955).

The reasons for this seasonal variation in the serum immune globulin concentration of colostrum-fed dairy calves are managerial in origin. During the winter, on most dairy farms in Scotland, calves are born in byres in which their dams are tied by the neck and subsequently active steps are taken to ensure that suckling does not take place (SELMAN *et al.*, 1971 *c*). These winter-born calves are usually quickly separated from their dams and are fed less than one litre of their dams colostrum following the next milking-time which means, in many cases, these may be a delay of 6-10 hours before colostrum is offered (SELMAN *et al.*, 1971 *c*). Such a practice ensures that the vast majority of calves born under these conditions in winter attain little or no colostrum protection (McEWAN *et al.*, 1970 ; SELMAN *et al.*, 1971 *c*).

These does not appear to be any other major factor responsible for the above seasonal variation in serum immune globulin concentrations in colostrum-fed dairy calves in Scotland. In particular, it should be noted that a seasonal variation in colostrum immune globulin concentration does not occur (SELMAN, 1969) and that low ambient temperatures do not depress the absorptive-efficiency of newborn dairy calves (SELMAN *et al.*, 1971 *b*).

3. *The effect of place of birth.*

The most recent large-scale survey in Britain indicated significant differences existed in neonatal calf mortality rate depending on where (*i. e.* byre, box or field) a calf was born : with mortality highest in byre-born calves and lowest in field-born calves (LEECH, *et al.*, 1968). A smaller survey carried out in Scotland confirmed that this was so, but also found that the place of birth also exerted a significant effect on the post-colostral serum immune globulin concentrations of the calves (SELMAN *et al.*, 1971 *c*). Thus, field-born calves had the highest, and byre-born calves the lowest, mean serum immune globulin concentrations, with box-born calves assuming an intermediate position. The reason for this would appear to be related to the ease with which early suckling can take place. The byre-born calf is usually subsequently found to be agammaglobulinaemic because it is generally fed too little colostrum, too late, and in the absence of its dam (see above). However, if special attention is paid by farmers to dairy calves which are born in byres during the winter it is possible to significantly increase the amount of immune globulin absorbed (SELMAN *et al.*, 1971 *c*).

4. *The effect of breed of calf.*

Surveys have repeatedly shown that *Ayrshire* calves tend to be more likely to succumb to neonatal disease than other breeds and crosses (WITHERS, 1952-1953 ; LEECH *et al.*, 1968). In fact, under controlled conditions, *Ayrshire* calves have been shown to absorb significantly less immune globulin than *Friesian-cross-Ayrshires*. However, the real importance of this observation is hard to assess mainly because breed differences in neonatal mortality rates of *colostrum-deprived* calves have been demonstrated (LUNDQUIST and PHILLIPS, 1943).

In addition, apparent breed differences in neonatal mortality rates of dairy calves can sometimes be attributable to variations in early calf management (SELMAN *et al.*, 1971 *c*).

C. — *Application of the above findings to a disease control programme*

Depriving a newborn calf of colostrum very commonly results in its death from one or other of the forms of colibacillosis. However, colostrum-feeding is no guarantee of survival and much depends on (*a*) the pathogenic challenge that a young calf is subjected to and (*b*) the efficiency with which it has absorbed immune globulins from its first meal of colostrum. The importance of an adequate degree of colostrum-derived protection and factors affecting the acquisition of this have been discussed. Using this information, it has been found to be possible to evolve a managerial routine which will ensure that most calves absorb immunologically adequate amounts of colostral globulins. The major points are as follows :

1. *The age at which colostrum is first ingested.*

In short, calves should be fed as soon as possible after birth.

It has been found to be possible to induce dairy calves to ingest 55 ml colostrum/kg (birth weight) at one hour *post partum* (SELMAN *et al.*, 1971) by artificial means

and to induce the suckling of even larger amounts before two hours of age (SELMAN *et al.*, 1971 *a* ; PETRIE, 1972 (Personal communication)). In most instances, if calves are allowed to suckle their dams, feeding can be safely delayed until six hours *post partum* (SELMAN *et al.*, 1971), but possibly the time factor for bucket-fed calves is much more critical (SELMAN *et al.*, 1971 *c*). It is particularly important to recognize that dairy calves left with their dams often do not suckle within the first six to eight hours of life even when well-mothered (SELMAN *et al.*, 1970 *b*). Therefore, it should never be assumed that, under these conditions, early suckling is inevitable.

2. *The amount of globulin ingested.*

In practice, the globulin content of a particular sample of bovine colostrum is not known, and in view of the wide individual variation which is known to exist (SELMAN, 1969), it would seem wise to encourage calves to consume maximal volumes. As already stated, intakes of 55 ml/kg (birth weight) are possible within two hours of birth when a teat-bucket is used. However, if one is merely encouraging a calf to suckle its dam as soon as possible after birth, larger amounts may be consumed only if the attendant is aware of the fact that the time taken to satiation is usually about 20 minutes (SELMAN *et al.*, 1971 *a* ; PETRIE, 1972 (personal communication)).

3. *The effect of the presence of the dam.*

This unexplained, but important, factor should not be ignored and wherever possible calves should be left with their dams for at least the first 12 hours of life. Even when such calves do not suckle and are fed artificially, the dam's presence appears to exert a beneficial effect (SELMAN *et al.*, 1971 *b*).

If implemented, the routines outlined above ensure that newborn calves absorb maximal quantities of immune globulins. However, in addition to increasing the resistance of young calves to neonatal disease one should attempt to decrease the pathogenic challenge that these animals are subjected to. Consequently, measures such as keeping young calves in small *self-contained* groups in new, or *efficiently* disinfected, premises should also be adopted wherever possible.

At the moment, there is little convincing evidence that under controlled conditions, prophylactic antibiotics are effective in controlling neonatal disease in calves, nor are any other proven alternative products available. Therefore, the above regime would appear to be the only method as yet at our disposal for combating neonatal disease in dairy herds. Inevitably, studies into the effect of this approach will need to be long-term and carried out under a variety of situations. Nevertheless, when we have obtained full co-operation from farmers, the benefits of such an approach have been most striking, and in several instances neonatal disease and death on hitherto problem farms have been markedly reduced or eliminated (PETRIE and SELMAN, to be published).

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RÉSUMÉ

L'ABSORPTION DES GLOBULINES COLOSTRALES
PAR LES VEAUX NOUVEAU-NÉS

Actuellement, il est reconnu que l'ingestion du colostrum par des veaux nouveaux-nés n'entraîne pas nécessairement l'absorption des globulines colostrales.

On discute ici les facteurs susceptibles d'affecter l'efficacité de l'absorption chez des veaux nouveaux-nés de race laitière. On discute également l'incidence des variations de la globulinémie sur la morbidité et la mortalité des nouveau-nés.

РЕЗЮМЕ

Абсорбция колостральных глобулинов новорожденными телятами.

В настоящее время известно, что поглощение колострума новорожденными телятами не обязательно влечет за собой абсорбцию колостральных глобулинов.

В этой работе авторы изучают факторы, которые могут влиять на эффективность абсорбции у новорожденных телят молочных пород. Обсуждается отражение вариации глобулинемии на заболеваемость и смертность новорожденных телят.

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